REPORT No. 424

WIND-TUNNEL RESEARCH COMPARING LATERAL CONTROL DEVICES, PARTICULARLY AT HIGH ANGLES OF ATTACK

IV—FLOATING TIP AILERONS ON RECTANGULAR WINGS

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SUMMARY

This report is the fourth of a series on systematic tests conducted by the National Advisory Committee for Aeronautics, which compare lateral control devices with particular reference to their effectiveness at high angles of attack. The present report covers tests with floating tip ailerons on rectangular Clark Y wings. Ailerons of two profiles were tested—symmetrical and Clark Y, both with adjustable trailing-edge flaps. Each form was tested at three hinge-axis locations, both with and without vertical end plates between the ailerons and the wing proper. The results from these tests are compared with the results from tests on a wing of the same over-all size equipped with average-sized ordinary ailerons.

All the wing-tip floating ailerons tested had about the same characteristics throughout except for their effect on the general performance of the wing. The general performance was found to be definitely poorer for all of the rectangular wings with floating tip ailerons than with a wing having the same over-all dimensions and ordinary ailerons. At the stall and just above, the rolling control was less than an assumed satisfactory value, but was appreciably better than with the standard wing with ordinary ailerons. At angles of attack above 22° the control with the wing-tip ailerons was found to be greater than the assumed satisfactory value, whereas the ordinary ailerons on the standard wing failed almost completely. The wings with floating tip ailerons gave no appreciable adverse yawing moments (body axis), but gave large favorable ones at high angles of attack. The instability in rolling was not as bad as for the wing with ordinary ailerons.

INTRODUCTION

This report describes the fourth of a systematic series of investigations in which it is hoped to compare all types of lateral control devices which have been satisfactorily used or which show reasonable promise of being effective. In this series of investigations it is planned first to test the various types of ailerons and other control devices on rectangular wings of aspect ratio 6. Later the best of these control devices are to be tested on wings with various amounts of taper and with different tip shapes. Still later the best control devices are to be tested on wings designed to improve lateral stability by giving them such features as washout, dihedral, and sweepback. In the entire series of investigations the various devices are to be subjected to the same program of wind-tunnel tests which, it is thought, include all factors directly connected with lateral control and stability that can be satisfactorily handled in a routine manner in a wind tunnel. The tests include regular 6-component force tests with the ailerons or other control devices both neutral and deflected various amounts; rotation tests in which the model is rotated about the tunnel, or wind, axis and the rolling moment measured; and free-rotation tests showing the range and rate of autorotation. Because of the large effect of yaw on the lateral stability, the tests are made not only at 0° yaw, but also with an angle of yaw of 20°, which represents the conditions in an average sideslip. The tests show the relative merit of the various control devices in regard to lateral controllability, lateral stability, and general performance as shown by the lift and drag characteristics.

The first report of this series (reference 1) deals with three sizes of ordinary ailerons. One of these is a medium-sized one taken from the average of a number of conventional airplanes and is used as the standard of comparison throughout the entire investigation. Other work that has been done in this series of investigations is reported in references 2 and 3.

The present report covers a similar, but preliminary, investigation on wings with floating wing-tip ailerons. A limited amount of work has been done previously on wings with floating ailerons (references 4 to 7), but the results are not sufficiently correlated and complete to cover all the main factors involved. The wings used in the present tests were rectangular in plan and the area of the ailerons was included as a part of the wing area. The tests were made with ailerons having two different airfoil sections, both forms being equipped with trailing-edge flaps. The ailerons were tested with three different axis locations, both with and without two types of end plates. Subsequent tests will be made with narrow chord and tapered floating wing-tip ailerons.

APPARATUS AND MODELS

Wind tunnel.—The 7 by 10 foot wind tunnel of the National Advisory Committee for Aeronautics, which is being used for the entire investigation, has an open jet and a single, closed return passage. The tunnel, the balance, and the associated apparatus are described in detail in reference 8.

For the force tests the model is mounted on a spindle attached to a floating framework surrounding the test section of the air stream. The balances are arranged to measure the six components of the aerodynamic forces and moments with respect to the wind axes. The floating angles of the ailerons are measured by an optical device mounted outside the air stream.

For free-autorotation and forced-rotation tests the model is mounted on a shaft on the jet center line. This shaft is driven through reduction gears by a small electric motor. The spindle and driving apparatus are mounted on the balance floating framework. In the free-autorotation tests the rate of rotation is determined and in the forced-rotation tests the rolling moment, while the model is rolling, is measured directly on the regular rolling-moment balance.

Models.—The wing models used were 10-inch chord Clark Y wings of aspect ratio 6. (Fig. 1.) Floating tip ailerons of 6-inch span were included as part of the wing. They were designed to give about the same rolling control at an angle of attack of 10° as the plain standard ailerons. (Reference 1.) The floating ailerons were secured to an interconnecting shaft supported on bearings in the wing proper. They could be locked on this shaft while deflected with respect to each other, but free to move with respect to the remainder of the wing. The ailerons were statically balanced about the hinge axis at any of the three axis locations; namely, 10 per cent, 15 per cent, and 20 per cent of the chord from the leading edge of the wing. (Fig. 1.) The tests were made on ailerons of two different profiles, the symmetrical N. A. C. A. 0010 and the Clark Y. The ailerons were equipped with adjustable trailing-edge flaps 20 per cent of the chord in width. As shown on Figure 1, two types of end plates were used, one triangular and the other circular.

The wing proper was constructed of laminated mahogany to an accuracy of ±0.005 inch. Metal bearings were set into the ends of the wing to support the aileron shaft. The ailerons were of composite construction. The leading edge nose piece ahead of the axis was made of lead or brass. The rest was built up, the ribs being of either mahogany or balsa wood and the covering of either paper or balsa wood. The form of the ailerons was not as accurately maintained as that of the remainder of the wing, owing to slight warpage and looseness of the paper covering caused by changing atmospheric conditions. The end plates were made of $\frac{1}{16}$-inch sheet aluminum.

TESTS AND RESULTS

All tests were made at a dynamic pressure of 16.37 pounds per square foot which corresponds to an air speed of 80 miles per hour under standard atmospheric conditions. The scale of all tests is the same, the Reynolds Number being 609,000.

Test to find the effect of axis location.—The first tests were made to determine the effect of the three axis locations. These tests were made on the wing with the symmetrical floating tip ailerons. The flaps were neutral and no end plates were used. The first tests on these models consisted of measuring the six components of aerodynamic forces and moments and the floating angles of the ailerons over an angle-of-attack range from −10° to +60°, with the ailerons floating with respect to the wing and locked neutral with respect to each other. These tests were made at both 0° and −20° yaw. Force tests were next made with the ailerons deflected with respect to each other, over an angle-of-attack range from 0° to 40°. The right aileron was deflected up and the left down. The 0° yaw tests were made with the ailerons deflected ±10°, ±20°, and ±30°. At −20° yaw the tests were made with only one aileron setting, ±20°. This aileron deflection is the maximum necessary to give the assumed satisfactory control, as determined from a number of flight tests (this subject is more fully discussed further on in this paper and in reference 1).

Under most conditions the ailerons floated satisfactorily; however, they fluttered violently at angles of attack between 9° and 14° when pivoted at the 20 per cent axis location and with the ailerons deflected ±20°.

The results of these tests are given in Tables I and II as absolute coefficients of lift and drag and rolling and yawing moments:

$$C_L=\frac{\text{Lift}}{q\,S}$$

$$C_D=\frac{\text{Drag}}{q\,S}$$

$$C_l'=\frac{\text{Rolling moment}}{q\,b\,S}$$

$$C_n'=\frac{\text{Yawing moment}}{q\,b\,S}$$

where S is the total wing area, b is the wing span, and q is the dynamic pressure. The coefficients as given above are obtained directly from the balance and refer to the wind (or tunnel) axes. In special cases in the discussion where the moments are used with reference to the body axes the coefficients are not primed. Thus, the symbols for the rolling and yawing moment coefficients about the body axes are, respectively, C_l and C_n.

The rolling and yawing moments at 0° yaw with ailerons deflected are the respective moments due to ailerons alone. At 20° yaw with the ailerons neutral the moments as given are due to yaw alone, but with the ailerons deflected they represent only the effect of the ailerons. The floating angles of the left aileron with respect to the chord of the model, designated δ_{AF}, are also included in these tables.

Rotation tests were also made on these three models at both 0° and 20° yaw. First, free-autorotation tests were made at 0° yaw, in which the model was mounted on the spindle, which was free to rotate. In these tests the range of angles of attack at which rotary instability occurred was determined and also the rate of rotation. The rate of rotation is expressed by the ratio $\frac{p'b}{2V}$; where p' is the rate of rotation in radians per second, b is the span of wing, and V is the velocity of air. Next, forced-rotation tests were made at a constant rate of rotation, with the model first at 0° and then 20° yaw. These tests were made at a rate of rotation corresponding to $\frac{p'b}{2V}=0.05$ which value, according to special flight tests, approximates the maximum rate of rolling caused by gusty air. (Reference 1.) In the forced-rotation tests the range of angles of attack at which rolling instability occurred and the intensity of the rolling instability were determined. The degree of the rolling instability is expressed in terms of the coefficient

$$C_\lambda=\frac{\lambda}{q\,b\,S}$$

where λ is the rolling moment due to the asymmetric distribution of the load along the span when the wing is rolling. The results of the free-autorotation tests are given in Table III and the results of the forced-rotation tests in Table IV. The coefficients as given above are with respect to the wind axis, which corresponds to the center line of the air stream.

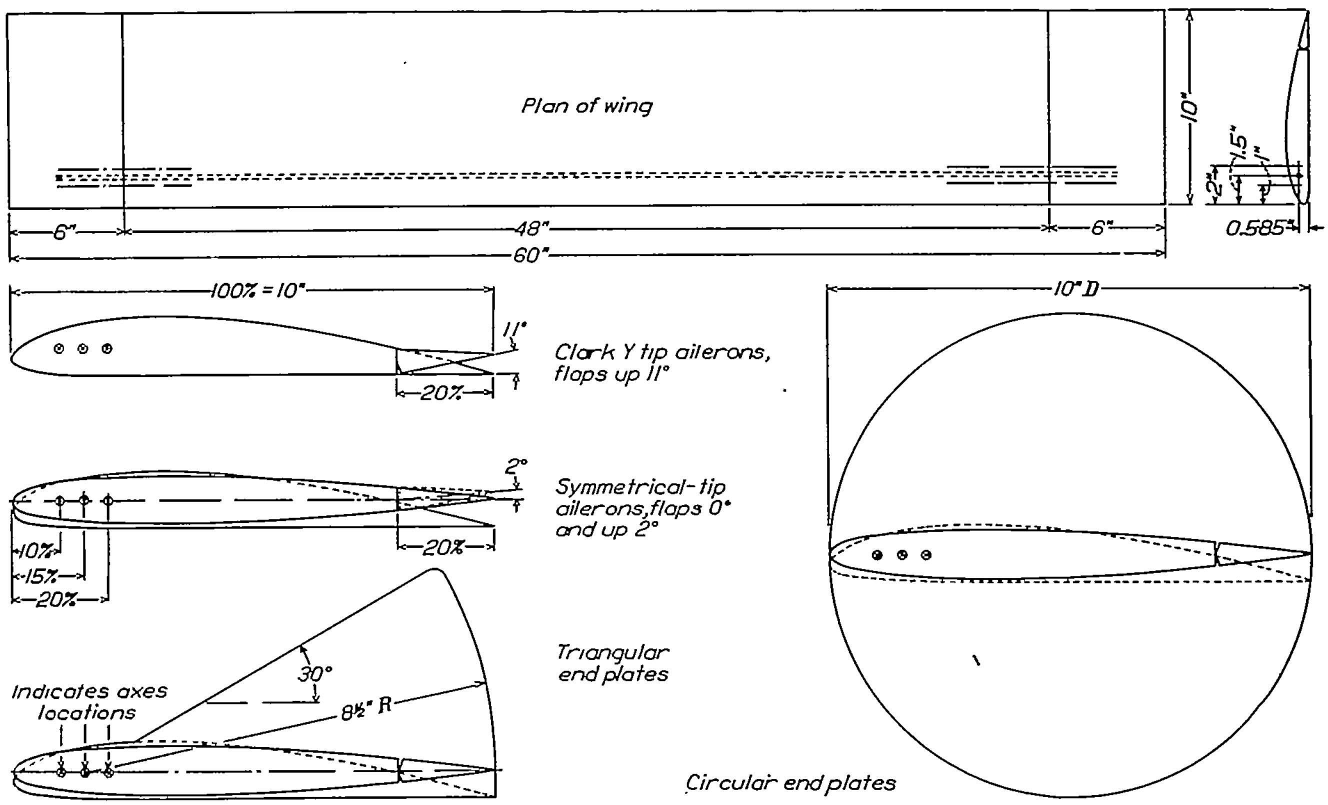

FIGURE 1.—Diagrams of the various model arrangements with floating tip ailerons

From a comparison of the results of these tests with the results of the tests on the wing with the standard ailerons (reference 1) it was found that the $C_{L\max}$ speed-range ratio, and rate of climb of the wings with floating-tip ailerons were much poorer. The control at high angles of attack, however, was better for all cases with floating tip ailerons. With the ailerons hinged at the 15 per cent axis location the results were superior to those at the other axis locations.

Tests to find the effect of end plates.—The effect of end plates was determined by making a regular series of force and rotation tests on the wing with the symmetrical tip ailerons hinged at the 15 per cent axis location, first with the triangular and then with the circular end plates. (Fig. 1.) The results of these tests are given in coefficient form in Tables V, VI, VII, and VIII. The triangular end plates increased the maximum lift slightly and decreased the minimum drag. They

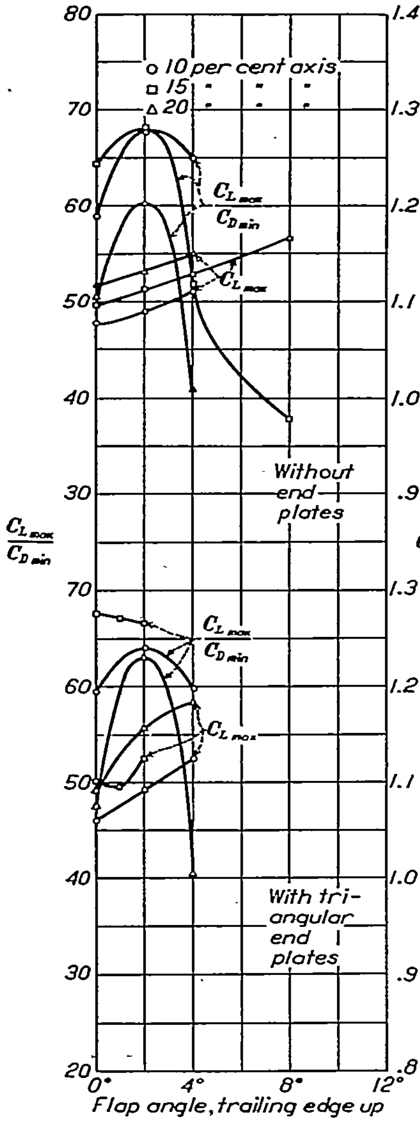

FIGURE 2.—Variation of maximum lift and the ratio of maximum lift to minimum drag with flap angle. Clark Y airfoil with N. A. C. A. 0010 symmetrical tip floating ailerons

also improved the control at 20° yaw. The circular end plates increased the maximum lift, but also increased the minimum drag, and improved the control at 20° yaw somewhat more than the triangular end plates. It was decided not to continue the tests with circular end plates, however, owing to the increase in minimum drag.

Tests with aileron flaps deflected.—Preliminary tests with the idea of improving the lift and drag characteristics with both types of floating tip ailerons were made with the aileron flaps deflected up various amounts. This flap deflection made the ailerons float at higher angles of attack.

The tests were made to determine the maximum lift and minimum drag coefficients only. Inasmuch as the effect of the flaps on maximum lift was small, the flap settings were in most of the cases varied throughout a sufficient range to find the highest value of the speed-range criterion, $C_{L\max}/C_{D\min}$. The tests were made with all three axis locations and both with and without the triangular end plates.

The results are given in Figures 2 and 3. With the symmetrical tip ailerons (fig. 2) the maximum value of the ratio $C_{L\max}/C_{D\min}$ occurs in nearly all six tests at a flap setting of about 2° up. Above this angle of attack as the flap angle increases, this ratio decreases, although the maximum lift continues to increase very slightly. With the flaps up 12°, however, the ailerons flutter violently. With the Clark Y ailerons, Figure 3 shows

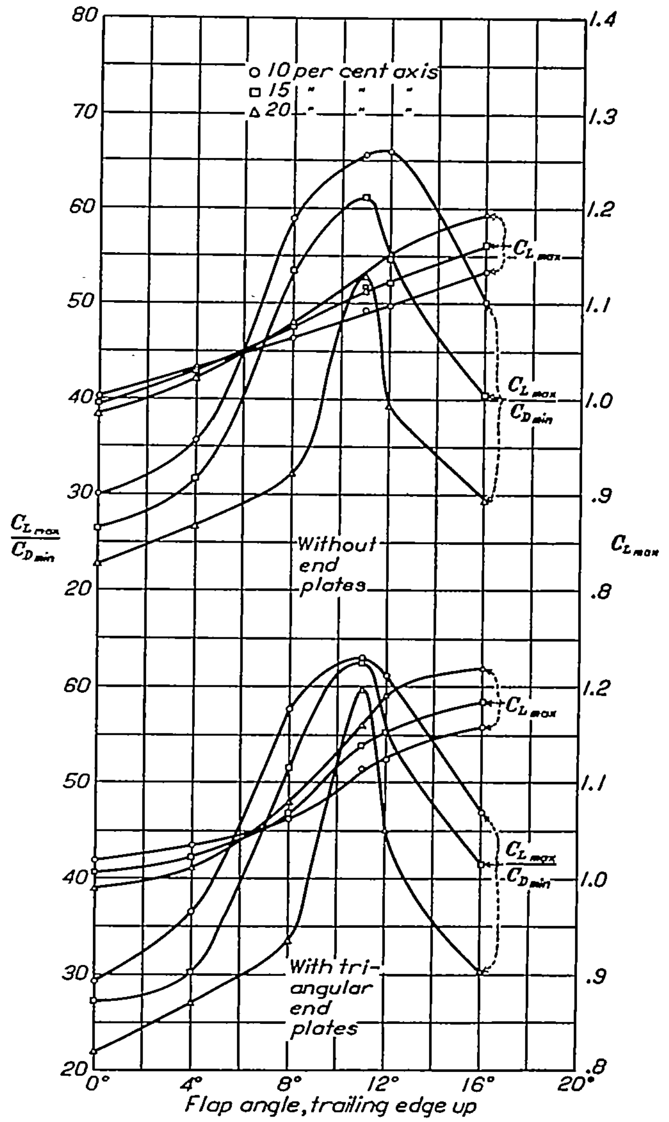

FIGURE 3.—Variation of maximum lift and the ratio of maximum lift to minimum drag with flap angle. Clark Y airfoil with Clark Y tip floating ailerons

that the highest ratio of maximum lift to minimum drag occurs for all tests with the flap up about 11°.

Tests were also attempted with the ailerons definitely unbalanced statically, in order to make them float at a higher angle of attack and thus increase the lift, but owing to excessive aileron flutter the tests could not be completed.

Final tests with best flap settings.—Final tests were made with the best flap settings as found above, with both sets of ailerons and all axis locations, both with and without triangular end plates. These tests consisted of complete force and rotation tests with the ailerons neutral, and complete force tests with ailerons deflected ±10°, ±20°, and ±30°, all at both 0° and 20° yaw. The test procedure and the angle-of-attack range were the same as for the first of the previously listed tests. The symmetrical tip ailerons with the flaps up 2° fluttered violently when deflected ±20°, from 9° to 14° angle of attack, when hinged at the 20 per cent axis location, both with and without the triangular end plates.

The force-test results with the symmetrical tip ailerons with the flaps up 2° and without end plates are given in Tables IX and X. The rotation-test results on the same models are given in Tables XI and XII. Likewise, the force and rotation test results on the same model with triangular end plates are given in Tables XIII and XIV, and XV and XVI, respectively. The results of the force and rotation tests on the wings with the Clark Y tip ailerons with flaps up 11°, with and without triangular end plates, are given in Tables XVII to XXIV.

Results of one of the tests with the symmetrical tip ailerons at the 15 per cent location, with flaps 0° and no end plates, are shown in Figure 4 for ailerons deflected ±20°. On the same figure, for comparison, the results are also given from the tests with the standard wing with 25 per cent chord by 40 per cent semispan ordinary ailerons deflected ±25°. These curves show the variation of the coefficient of rolling moment due to ailerons, for a given aileron deflection, over an angle-of-attack range from 0° to 40°. A comparative study of the curves shows that the rolling moment with the plain ailerons deflected ±25° is about the same as the rolling moment with the floating tip ailerons deflected ±20° up to 15° angle of attack. Above this angle of attack the rolling moment drops very rapidly for the ordinary plain ailerons, whereas with the floating-tip ailerons the rolling moment increases to a maximum at 22° angle of attack. As the angle of attack is increased above 22° the rolling moment decreases, but not at a very rapid rate. The curve for the tip-aileron rolling moments shown in this figure is representative of all the tip ailerons tested.

Compound floating-tip ailerons.—Tests were also tried with the ailerons floating independently of each other and controlled by varying the flap angle to obtain the rolling moments. This aileron arrangement is designated *compound floating tip ailerons*. With the flap set up 10° on one aileron and down 10° on the other a rolling-moment coefficient of about 0.040 was obtained. At higher flap settings the ailerons fluttered violently. Since the above-mentioned rolling-moment coefficient was not considered satisfactory these tests were not continued.

Accuracy.—The accuracy of the results given in this report is the same as that obtained in Part I. (Reference 1.) It is considered satisfactory at all angles of attack except in the burbled region between 20° and 25°. In this region the rolling and yawing moments are relatively unreliable owing to the critical and often

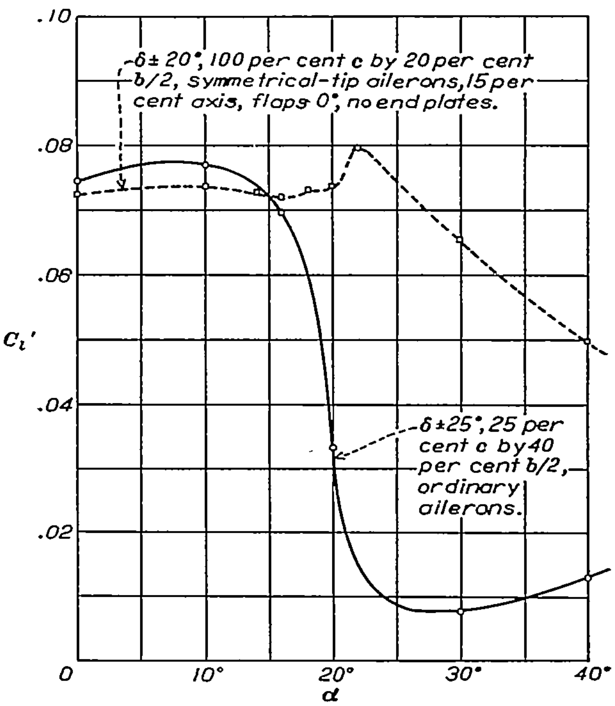

FIGURE 4.—Comparison of rolling moments due to ordinary ailerons with rolling moments due to floating tip ailerons. Clark Y airfoil Yaw=0°

unsymmetrical condition of the burbled air flow around the wing.

DISCUSSION OF RESULTS

For a comparison of the different aileron effects the results of the tests are discussed in terms of criterions which are explained in detail in reference 1 and briefly in the following paragraphs. By use of these criterions a comparison of the effect of the different ailerons on the general performance, the lateral controllability, and the lateral stability may be easily made. The results of the above tests in terms of the criterions are given in Table XXV. The criterions for the following aileron arrangements are included in the table for comparison: The wing with the 25 per cent chord by 40 per cent semispan ordinary ailerons, which is used as the standard; and the wing with the 40 per cent chord by 30 per cent semispan ordinary ailerons rigged up 10° when neutral, which is the best of the previously tested ailerons.

GENERAL PERFORMANCE

Wing area required for desired landing speed.—The criterion $C_{L_{max}}$ is used to indicate the wing area required for a given landing speed, or conversely, for the minimum landing speed obtainable with a given wing area. The coefficient as used herein is based on the entire wing area, including the ailerons. The use of this area in calculating the coefficients was considered a fair basis for comparing floating tip ailerons with ordinary ailerons as the ailerons represent additional structural weight and span.

A comparison of the maximum lift coefficients obtained with the wings equipped with floating tip ailerons and the maximum lift coefficient of the standard wing with ordinary ailerons (Table XXV) shows that the floating tip ailerons decreased the maximum lift coefficient by 10 to 15 per cent. The effects of the changes in aileron arrangements were small. Maximum lift was increased by 3 to 6 per cent as the axis of the ailerons was moved back from the 10 per cent to the 20 per cent location. It was also improved from 1 to 2 per cent by putting the flaps up 2° on the symmetrical tip aileron. The triangular or circular end plates increased the maximum lift from 0 to 3 per cent. Figures 2 and 3 show that the maximum lift was increased still higher as the flap angle was increased beyond the setting for the highest ratio of maximum lift to minimum drag.

Speed range.—The criterion for speed range was taken as the ratio of the maximum lift coefficient to the minimum drag coefficient. In all cases with the floating tip ailerons the speed-range ratio is lower than for the standard wing with ordinary ailerons. (Table XXV.) This lower value of the speed-range ratio is due to both the decrease in maximum lift and the increase in minimum drag with the floating tip ailerons. The minimum drag, which varies with the floating angle of the ailerons, has the greater effect of the two. With the wing-tip ailerons the floating angle of the ailerons was different if the angle of attack of minimum drag was approached from a lower angle of attack than if approached from a higher angle. The value of minimum drag as obtained when the angle of attack was decreased to the angle for minimum drag was always the lower and is used in calculating the speed-range ratio in every case. This should be a fair basis of comparison, because in flight the low angle of attack, or high speed, condition is always approached from a high angle of attack, or low speed, condition.

The highest value of the speed-range ratio, which is about 15 per cent lower than that for the standard wing, was obtained with the symmetrical tip ailerons hinged at the 15 per cent axis location, with the flaps neutral and the triangular end plates in place. The ratio was about the same with the symmetrical tip ailerons with the flaps up 2°, without end plates for both the 10 and the 15 per cent axis locations. The value for the 20 per cent axis location was worse in every case than for the 10 and 15 per cent locations. The ailerons with the Clark Y section gave results not quite as good as those obtained with the symmetrical tip ailerons, other conditions being the same.

Rate of climb.—The criterion for the rate of climb as used in Table XXV is the ratio of lift to drag at a lift coefficient of 0.70. None of the wings with tip ailerons is as good as the standard wing with ordinary ailerons in this respect. With either set of tip ailerons at the 20 per cent axis with flaps up the best amount and triangular end plates, the rate-of-climb criterion is only 2 per cent less than for the standard wing. The value of the criterion decreases as the axis is moved ahead to the 10 per cent position. The lowest values are for the symmetrical tip ailerons with flaps 0° and no end plates, in which case the average value for all three axis locations is about 20 per cent lower than for the standard wing. The rate-of-climb criterion for the wing with the ordinary short, wide ailerons rigged up 10° when neutral is about 10 per cent higher than the best of the wings with the floating-tip ailerons.

LATERAL CONTROLLABILITY

Rolling criterion.—The rolling criterion upon which the control effectiveness of each of the aileron arrangements is judged is a figure of merit that is designed to be proportional to the initial accelleration of the wing tip that follows a deflection of the ailerons from neutral, regardless of the air speed or the plan form of the wing. Expressed in coefficient form for a rectangular monoplane wing the criterion is

$$RC=\frac{C_l}{C_L}$$

where C_l is the rolling-moment coefficient about the body axis due to the ailerons. The numerical value of this expression that has been found to represent satisfactory control conditions is approximately 0.075. A more detailed explanation of the derivation of RC and of its more general form which is applicable to any wing plan form is given in reference 1.

The comparison of the ailerons on the basis of this criterion is given in Table XXV at four representative angles of attack; namely, 0°, 10°, 20°, and 30°. The 0° angle represents the high-speed attitude; $\alpha=10°$ represents the highest angle of attack at which entirely satisfactory control with ordinary ailerons can be maintained; $\alpha=20°$ is the condition of greatest lateral instability and is probably the greatest obtainable angle of attack in a steady glide with most present-day airplanes; and finally, $\alpha=30°$ is given only for comparison with controls for possible future types of airplanes.

At 0° angle of attack or at high speed all the floating tip ailerons give very high values of RC. They are like the standard plain ailerons in that at high speed they give more control than is necessary.

At 10°, or the highest angle of attack at which the standard ailerons give entirely satisfactory control (and which is also the condition for which all ailerons were designed to give the same control), the values of *RC* for all floating tip ailerons fall within reasonable limits of that for the standard wing with ordinary ailerons. These ailerons may be arranged to give the same value of *RC* at this angle of attack by simply changing their maximum assumed deflection.

At $\alpha=20°$ none of the floating wing-tip ailerons gives entirely satisfactory control. The values vary from 67 to 87 per cent of the respective values at 10° angle of attack. End plates have an adverse effect on the control at this angle of attack for all tip ailerons.

All the floating tip ailerons give better control at $\alpha=20°$ than the standard ailerons. The values of *RC* for the wing with the standard ailerons with equal up-and-down aileron displacement, and for the wing with short, wide ailerons rigged up 10° when neutral and having an extreme differential movement, are shown in Figure 5 along with a typical set of results for the floating tip ailerons (symmetrical tips with flaps 0°, 15 per cent axis location, and no end plates).

If, as seems hardly probable, it is desired to fly at an angle of attack appreciably higher than 20°, floating tip ailerons will give satisfactory control. At an angle of attack of 30° all the floating tip ailerons give an excess of control over that considered satisfactory, whereas all ordinary ailerons fail almost completely.

Lateral control with sideslip.—If a wing is yawed appreciably a rolling moment is set up that tends to raise the forward tip with a magnitude that is always greater, at very high angles of attack, than the available rolling moment due to ordinary ailerons. The highest angle of attack at which the ailerons can balance the rolling moment due to 20° yaw is tabulated for all aileron arrangements as a criterion of control with sideslip. As previously mentioned 20° yaw represents the conditions in an average sideslip.

Referring again to Table XXV it may be seen that without end plates the control against 20° sideslip is maintained up to about the same angle of attack (20°) with any of the floating tip ailerons as with the standard ordinary ailerons. With triangular end plates the tip ailerons give slightly better control than the standard ordinary ailerons, the critical angle being from 3° to 5° higher. The wing with the ordinary short, wide ailerons, rigged up 10° when neutral and having an extreme differential movement is still better, however, having control against sideslip up to an angle of attack of 26°. With the circular end plates the control is still better, being sufficient to give control at all angles of attack.

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Yawing moment due to ailerons.—The desirable yawing moment due to ailerons depends to some extent upon the type of airplane that is being considered. For highly maneuverable military or acrobatic machines, complete independence of the controls as they affect the turning moments about the various body axes is no doubt a desirable feature. On the other hand, for large transport airplanes or for machines to be operated by relatively inexperienced pilots, a favorable

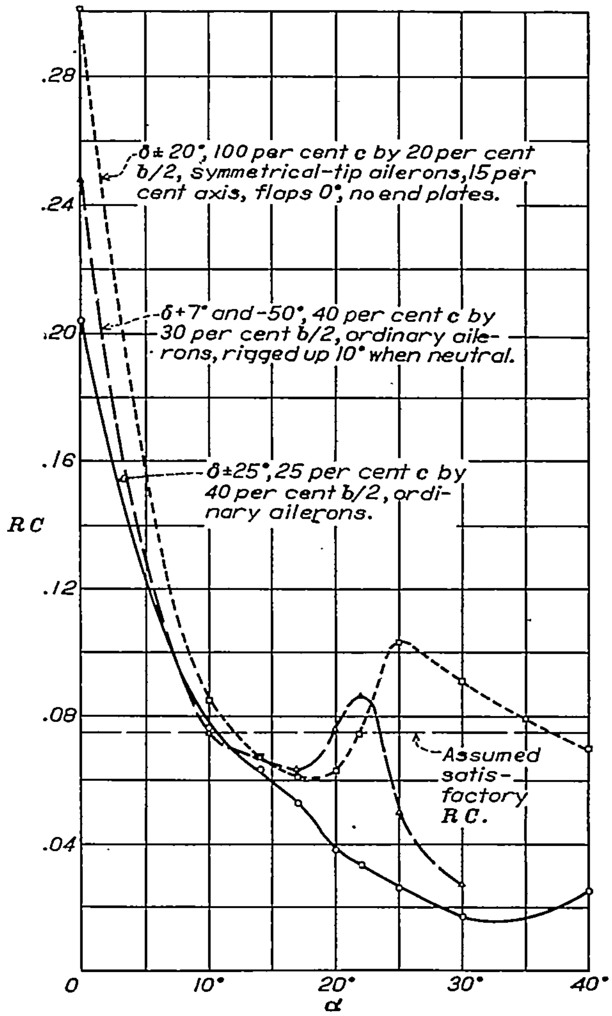

FIGURE 5.—Comparison of the values of *RC* for three aileron arrangements. Clark Y airfoil

yawing moment of proper magnitude would be an appreciable aid to safe flying at high angles of attack, where the secondary rolling moment produced by the resulting yawing motion of the airplane would help the usually inadequate rolling moment of the ailerons alone. Finally, it is obvious that a yawing moment tending to turn the airplane out of its bank is never desirable under any circumstances.

From an inspection of Table XXV it may be seen that none of the wings with floating tip ailerons give appreciable adverse yawing moments, and the negligible adverse yawing moments which do occur are at the high-speed condition only. All the floating tip ailerons give large favorable yawing moments about the body axes at high angles of attack. At 10° angle of attack the favorable yawing moment is about 1½ times more than can be obtained with an average rudder, and at 20° angle of attack the ailerons give about four times as much yawing moment as an average rudder. At all angles of attack the yawing moments about the wind axes are small, which explains the small yawing moments about the body axes at high speeds or low angles of attack where the two sets of axes tend to become the same. All wings with the floating tip ailerons are superior to the standard wing with plain ailerons in this respect. The yawing moment coefficients about the body axis, C_n, with the short, wide ailerons rigged up 10° and operated with extreme differential movement are, however, about the same as those with the floating tip ailerons.

LATERAL STABILITY

Angle of attack above which autorotation is self-starting.—The first criterion of lateral stability is the angle of attack above which the airfoil will start to rotate if mounted on a free shaft parallel to the jet axis. All the wings with floating tip ailerons are laterally stable up to an angle of attack within 1° of 19° which is the same as the standard wing with ordinary ailerons. This angle is about 3° greater than the angle of attack of maximum lift.

Stability against rolling caused by gusts.—This is a more severe criterion than the preceding one. It represents the condition of maximum rolling due to gusty air while attempting level flight. This rate of rolling was found from flight tests to correspond to approximately $\frac{p'b}{2V}=0.05$. (Reference 1.) In all cases at 0° yaw the angle of initial instability in rolling at $\frac{p'b}{2V}=0.05$ is from 1° to 2° less than that at which autorotation is self-starting. It is about the same as for the wing with standard ailerons.

For 20° yaw and all cases without end plates the wings, like the one with standard ailerons, were unstable at angles of attack greater than 9° to 11°. The triangular end plates increased these angles of attack for initial instability to from 12° to 16°, the largest angles being obtained with the Clark Y ailerons hinged at the rearmost axis location.

The above criterion shows only the angle of initial instability in rolling. Another criterion that shows the degree of the lateral instability is the maximum unstable rolling moment while the model is rolling, C_λ. All the wings showed unsymmetrical conditions in the two directions of rotation. The highest value of unstable C_λ in either direction of rotation is given in Table XXV. The values of C_λ at 0° yaw for the wings with floating tip ailerons are about half as great as for the standard wing with plain ailerons and about the same as with the short, wide ailerons rigged up 10° when neutral. At an angle of yaw of 20°, the maximum values of C_λ with the floating tip ailerons were in all cases about one-third lower than with the ordinary standard ailerons, and were slightly lower than with the ordinary short, wide ailerons rigged up 10° when neutral.

CONTROL FORCE REQUIRED

In the tests herein reported the hinge moments were not measured. When the best floating tip ailerons have been found the hinge moments will be determined if the ailerons are considered of sufficient interest. It is, of course, evident that the hinge moments will be less for the 20 per cent axis than for the 15 per cent axis, and less for the 15 per cent axis than for the 10 per cent axis.

AILERON FLUTTER

At angles of attack above the stall all the floating tip ailerons showed slightly unsteady characteristics; that is, they fluctuated as much as a degree, but not at regular intervals. This fluctuation may have been caused by slight movements of the wing due to the burbled air flow above the stall. With the symmetrical tip ailerons hinged on the 20 per cent axis and the flaps 0° or up 2°, both with and without the triangular end plates, there was a very violent flutter with the ailerons deflected ±20°. This flutter occurred over an angle-of-attack range from 9° to 14°. It had an amplitude of 3° or 4° and was so violent that balance readings could not be taken.

POSSIBILITY OF CONTROL OF FLAPS ON TIP AILERONS

If the flaps on the wing-tip ailerons were made to be controllable in flight the general efficiency of the wings with floating tip ailerons could be greatly improved. The maximum lift coefficient could be increased by moving the flaps up for the conditions of take-off and landing. The rate of climb and the minimum drag could likewise be improved by proper adjustment of the aileron flap angle.

CONCLUSIONS

1. The general performance, including the wing area required for a given minimum speed, the speed range, and the rate of climb, was found to be definitely poorer for the rectangular wings with floating tip ailerons

than with a wing having the same over-all dimensions and ordinary ailerons.

2. With the flaps turned up a small amount the floating tip ailerons of symmetrical section gave a slightly higher maximum lift coefficient, speed-range ratio, and climbing criterion.

3. None of the present floating tip ailerons on rectangular wings gave entirely satisfactory rolling control just above the stall ($\alpha=20°$), but some gave within 20 per cent of the assumed satisfactory *RC*.

4. At an angle of attack of 20° the floating tip ailerons gave greater control than the standard ailerons, but less than the short, wide ailerons rigged up 10° when neutral and operated with an extreme differential movement.

5. The wings with floating tip ailerons gave no appreciable adverse yawing moments (body axis), but gave large favorable ones at high angles of attack.

6. Instability in rolling was not as bad with the floating tip ailerons as for the standard ailerons, but was slightly worse at 0° yaw than with plain short, wide ailerons rigged up 10° when neutral.

7. End plates had relatively small effects.

8. The differences between the results with the symmetrical and the Clark Y tip ailerons, with the flaps in each case turned up the optimum amount, were small.

9. The tests indicated that the following aileron arrangements are unsatisfactory because of excessive flutter.

a. The ailerons of symmetrical section floating at the 20 per cent axis location with flaps 0° or up 2°, either with or without end plates.

b. Ailerons unbalanced statically to improve the general performance.

c. Ailerons floating independently and controlled by flaps to give the desired rolling moments.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *February 18, 1932*.

REFERENCES

1. Weick, Fred E., and Wenzinger, Carl J.: Wind-Tunnel Research Comparing Lateral Control Devices, Particularly at High Angles of Attack. I. Ordinary Ailerons on Rectangular Wings. T. R. No. 419, N. A. C. A., 1932.
2. Weick, Fred E., and Noyes, Richard W.: Wind-Tunnel Research Comparing Lateral Control Devices, Particularly at High Angles of Attack. II. Slotted Ailerons and Frise Ailerons. T. R. No. 422, N. A. C. A., 1932.
3. Weick, Fred E., and Wenzinger, Carl J.: Wind-Tunnel Research Comparing Lateral Control Devices, Particularly at High Angles of Attack. III. Ordinary Ailerons Rigged up 10° When Neutral. T. R. No. 423, N. A. C. A., 1932.
4. Bradfield, F. B., and Peatfield, I. L.: Lateral Control at Low Speeds. R. & M. No. 717, British A. R. C., 1920.
5. Bradfield, F. B., and Simmonds, O. E.: Rolling and Yawing Moments Due to Roll of Model Avro Wings, with Standard and Interplane Ailerons, and Rudder Moments, for Standard and Special Large Rudder. R. & M. No. 848, British A. R. C., 1922.
6. Knight, Montgomery, and Bamber, Millard J.: Wind-Tunnel Tests on a Model of a Monoplane Wing with Floating Ailerons. T. N. No. 316, N. A. C. A., 1929.
7. Knight, Montgomery, and Wenzinger, Carl J.: The Effect of Wing-Tip Floating Ailerons on the Autorotation of a Monoplane Wing Model. T. N. No. 336, N. A. C. A., 1930.
8. Harris, Thomas A.: The 7 by 10 Foot Wind Tunnel of the National Advisory Committee for Aeronautics. T. R. No. 412, N. A. C. A., 1932.

TABLE I

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

α		−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.246	−0.053	0.063	0.238	0.546	0.829	0.929	1.013	1.074	1.070	1.058	1.040	0.958	0.635	0.635	0.616	0.568	0.488
C_D	0°	.054	.028	.018	.022	.042	.076	.091	.109	.129	.142	.158	.187	.216	.321	.394	.544	.697	.824
δ_{AF}	0°	13°	−2°	−4°	−8°	−12°	−16°	−18°	−19°	−20°	−20.5°	−21°	−22°	−23°	−25°	−28°	−39°	−50°	−57°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°				0.035		0.037		0.037	0.036		0.037	0.037	0.036		0.034	0.023		
C_n'	10°				.002		.005		.005	.005		.005	.005	.003		−.004	−.004		
δ_{AF}	10°				6°		−6°		−10°	−11°		−13°	−14°	−15°		−23°	−32°		
C_l'	20°				.071		.074		.074	.073		.075	.075	.078		.066	.050		
C_n'	20°				.002		.005		.007	.007		.007	.007	.004		−.003	−.006		
δ_{AF}	20°				19°		8°		3°	1°		−1°	−2°	−4°		−13°	−17.5°		
C_l'	30°				.103		.091		.084	.081		.076	.071	.079		.091	.074		
C_n'	30°				.002		.004		.004	.004		.003	.002	.000		−.004	−.006		
δ_{AF}	30°				29°		19°		15°	13°		12°	11°	10°		−7°	−14°		
AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																			
C_L	0°	−0.124	0.032	0.065	0.237	0.556	0.845	0.954	1.042	1.098	1.094	1.085	1.064	0.982	0.655	0.642	0.629	0.585	0.502
C_D	0°	.044	.017	.018	.022	.041	.073	.089	.106	.125	.139	.156	.188	.215	.321	.392	.545	.694	.847
δ_{AF}	0°	18°	10°	−3°	−7°	−10°	−14°	−15°	−16°	−17°	−18°	−18.5°	−19.5°	−20°	−21°	−27°	−37°	−45°	−53°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°				0.035		0.037		0.038	0.038		0.039	0.039	0.038		0.035	0.024		
C_n'	10°				.001		.004		.004	.004		.004	.003	.001		−.004	−.006		
δ_{AF}	10°				9°		−4°		−7°	−9°		−10°	−12°	−12°		−21°	−30°		
C_l'	20°				.072		.073		.073	.072		.073	.073	.080		.065	.049		
C_n'	20°				.001		.003		.005	.005		.005	.005	.002		−.004	−.007		
δ_{AF}	20°				20°		7°		3°	1°		−1°	−3°	−4°		−13°	−21°		
C_l'	30°				.103		.088		.078	.074		.068	.063	.072		.087	.071		
C_n'	30°				.001		.002		.001	.000		.000	−.001	−.002		−.002	−.009		
δ_{AF}	30°				29°		20°		16°	15°		14°	13°	11°		−5°	−12°		
AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																			
C_L	0°	−0.189	0.084	0.025	0.212	0.537	0.855	0.962	1.056	1.112	1.117	1.098	1.084	0.999	0.668	0.645	0.637	0.602	0.521
C_D	0°	.045	.022	.022	.025	.043	.071	.088	.103	.125	.138	.155	.186	.216	.326	.393	.549	.702	.837
δ_{AF}	0°	21°	15°	−7°	−10°	−13°	−13°	−14°	−15°	−16°	−17°	−17°	−18°	−18°	−20°	−28°	−36°	−41°	−49°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°				0.036		0.036		0.037	0.036		0.037	0.037	0.036		0.034	0.024		
C_n'	10°				.003		.004		.003	.003		.003	.003	.000		−.005	−.005		
δ_{AF}	10°				8°		−4°		−7°	−9°		−10°	−11°	−11°		−21°	−31°		
C_l'	20°				.073		.071		.071	.070		.071	.072	.079		.065	.049		
C_n'	20°				.001		.002		.004	.004		.005	.004	.001		−.005	−.008		
δ_{AF}	20°				20°		9°		4°	1°		0°	−2°	−4°		−13°	−22°		
C_l'	30°				.105		.087		.080	.072		.068	.064	.073		.090	.070		
C_n	30°				.001		.003		.002	.001		.001	.001	.000		−.001	−.010		
δ_{AF}	30°				30°		20°		16°	15°		14°	13°	11°		−4°	−15°		

TABLE II

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

α		−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.237	−0.002	0.075	0.226	0.499	0.748	0.837	0.912	0.972	0.996	1.014	1.031	1.011	0.702	0.653	0.633	0.587	0.490
C_D	0°	.036	.017	.018	.023	.042	.072	.086	.100	.119	.129	.140	.176	.218	.335	.387	.533	.681	.804
C_l'	0°	.009	−.001	−.005	−.011	−.017	−.022	−.024	−.027	−.033	−.038	−.043	−.062	−.063	−.064	−.042	−.028	−.024	−.021
C_n'	0°	.001	.002	.001	.002	.002	.004	.005	.006	.008	.009	.010	.012	.014	.024	.024	.026	.032	.033
δ_{AF}	0°	14°	1°	−4°	−7°	−11°	−16°	−19°	−21°	−22°	−23°	−24°	−25°	−27°	−30°	−36°	−48°	−57°	−69°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.069	--------	0.071	--------	0.072	0.071	--------	0.069	0.067	0.067	--------	0.040	0.029	--------	--------
C_n'	20°	--------	--------	--------	−.003	--------	−.000	--------	.000	.001	--------	.000	−.001	−.002	--------	−.006	−.006	--------	--------
δ_{AF}	20°	--------	--------	--------	24°	--------	9°	--------	3°	.5°	--------	−.5°	−1.5°	−2.5°	--------	−5°	−15°	--------	--------
		AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																	
C_L	0°	−0.028	0.012	0.088	0.232	0.507	0.759	0.848	0.928	0.992	1.012	1.032	1.048	1.017	0.714	0.657	0.643	0.597	0.501
C_D	0°	.037	.017	.017	.022	.040	.069	.084	.099	.115	.125	.138	.172	.214	.335	.387	.536	.686	.811
C_l'	0°	.009	.002	−.003	−.009	−.015	−.020	−.022	−.025	−.033	−.037	−.043	−.064	−.065	−.064	−.044	−.030	−.026	−.024
C_n'	0°	.002	.002	.002	.002	.002	.004	.005	.006	.008	.009	.010	.013	.015	.024	.024	.026	.032	.035
δ_{AF}	0°	17°	7°	−2°	−4°	−9°	−14°	−16°	−17°	−18°	−19°	−20°	−24°	−25°	−29°	−33°	−45°	−55°	−65°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.066	--------	0.069	--------	0.070	0.067	--------	0.065	0.064	0.059	--------	0.037	0.028	--------	--------
C_n'	20°	--------	--------	--------	−.004	--------	−.001	--------	−.001	.000	--------	−.001	−.003	−.004	--------	−.008	−.008	--------	--------
δ_{AF}	20°	--------	--------	--------	24°	--------	13°	--------	4°	3°	--------	2°	2°	1°	--------	−2°	−11°	--------	--------
		AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																	
C_L	0°	−0.110	0.007	0.071	0.226	0.504	0.764	0.859	0.945	1.006	1.022	1.045	1.054	1.023	0.715	0.655	0.637	0.591	0.497
C_D	0°	.036	.017	.019	.023	.040	.068	.082	.097	.114	.122	.134	.170	.214	.332	.386	.535	.687	.810
C_l'	0°	.008	.000	−.006	−.010	−.015	−.019	−.022	−.025	−.033	−.038	−.045	−.066	−.068	−.066	−.044	−.031	−.026	−.026
C_n'	0°	.002	.002	.002	.002	.002	.004	.005	.006	.008	.009	.010	.012	.014	.024	.026	.026	.032	.035
δ_{AF}	0°	16°	6°	−1°	−5°	−10°	−14°	−16°	−17°	−18°	−19°	−20°	−22°	−23°	−27°	−33°	−45°	−56°	−63°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.066	--------	Flutter	--------	0.068	0.067	--------	0.065	0.064	0.060	0.041	0.032	0.025	--------	--------
C_n'	20°	--------	--------	--------	−.006	--------	do	--------	−.001	.000	--------	.000	−.002	−.004	−.009	−.010	−.008	--------	--------
δ_{AF}	20°	--------	--------	--------	25°	--------	do	--------	6°	4°	--------	2°	1°	0°	3°	−2°	−10°	--------	--------

TABLE III

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}$=0.05, (+) aiding rotation, (−) damping rotation; $\frac{p'b}{2V}$ values are for free autorotation

	α	0°	12°	14°	16°	18°	19°	20°	21°	22°	23°	24°	25°	30°	40°
10 per cent axis															
(+) Rotation (clockwise)	C_λ	−0.022	−0.019	−0.017	−0.014	−0.004	--------	0.019	--------	0.011	--------	--------	−0.004	−0.010	−0.008
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	0.060	.163	0.154	.149	0.123	0.031	.031	--------	--------
(−) Rotation (counter-clockwise).	C_λ	−.023	−.020	−.018	−.015	−.010	--------	.010	--------	−.001	--------	--------	−.007	−.008	−.007
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	--------	.143	--------	--------	--------	--------	--------	--------	--------
15 per cent axis															
(+) Rotation (clockwise)	C_λ	−0.024	−0.021	−0.019	−0.016	−0.005	--------	0.016	--------	0.008	--------	--------	−0.005	−0.011	−0.009
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	{0.072 .172}	.167	0.158	.151	0.116	0.022	--------	--------	--------
(−) Rotation (counter-clockwise).	C_λ	−.021	−.017	−.016	−.013	−.007	--------	.010	--------	−.001	--------	--------	−.006	−.007	−.005
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	--------	.157	.147	--------	--------	--------	--------	--------	--------
20 per cent axis															
(+) Rotation (clockwise)	C_λ	−0.025	−0.021	−0.018	−0.016	−0.006	--------	0.017	--------	0.005	--------	--------	−0.007	−0.010	−0.009
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	0.165	.165	0.160	.149	--------	--------	--------	--------	--------
(−) Rotation (counter-clockwise).	C_λ	−.021	−.017	−.016	−.013	−.007	--------	.011	--------	−.001	--------	--------	−.007	−.007	−.005
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	.154	.160	.149	--------	--------	--------	--------	--------	--------

TABLE IV

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation

	α	0°	12°	14°	16°	18°	20°	22°	25°	30°	40°
10 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.011	0.007	0.011	0.018	0.028	0.043	0.061	0.053	0.028	0.016
(+) Rotation (clockwise)	C_λ	−.031	−.045	−.048	−.054	−.063	−.073	−.073	−.062	−.044	−.035
15 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.014	0.005	0.009	0.016	0.026	0.043	0.061	0.053	0.032	0.016
(+) Rotation (clockwise)	C_λ	−.030	−.044	−.048	−.051	−.060	−.070	−.073	−.063	−.043	−.035
20 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.015	0.004	0.008	0.015	0.027	0.044	0.062	0.054	0.032	0.015
(+) Rotation (clockwise)	C_λ	−.031	−.043	−.046	−.051	−.061	−.070	−.074	−.062	−.045	−.034

TABLE V

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°; 15 PER CENT AXIS

α		−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	**AILERONS FLOATING, NEUTRAL—CIRCULAR END PLATES**																	
C_L	0°	−0.215	0.047	0.158	0.305	0.609	0.885	0.982	1.055	1.102	1.080	1.066	0.989	0.925	0.616	0.620	0.605	0.540	0.457
C_D	0°	.059	.019	.018	.021	.042	.075	.092	.109	.129	.146	.162	.193	.220	.320	.390	.543	.701	.854
δ_{AF}	0°	19°	11°	7°	−1°	−9°	−16°	−18°	−20°	−22°	−24°	−26°	−27°	−29°	−22°	−28°	−39°	−50°	−57°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°	--------	--------	--------	0.032	--------	0.030	--------	0.023	0.030	--------	0.029	0.028	0.029	--------	0.038	0.030	--------	--------
C_n'	10°	--------	--------	--------	.001	--------	.002	--------	.003	.003	--------	.004	.003	.003	--------	−.002	−.004	--------	--------
δ_{AF}	10°	--------	--------	--------	9°	--------	−3°	--------	−8°	−10°	--------	−12°	−14°	−16°	--------	−20°	−30°	--------	--------
C_l'	20°	--------	--------	--------	.069	--------	.065	--------	.064	.063	--------	.063	.061	.063	--------	.080	.076	--------	--------
C_n'	20°	--------	--------	--------	.001	--------	.005	--------	.006	.006	--------	.006	.005	.004	--------	−.003	−.005	--------	--------
δ_{AF}	20°	--------	--------	--------	20°	--------	8°	--------	3°	0°	--------	−1°	−4°	−6°	--------	−11°	−20°	--------	--------
C_l'	30°	--------	--------	--------	.084	--------	.080	--------	.080	.079	--------	.077	.069	.088	--------	.100	.092	--------	--------
C_n'	30°	--------	--------	--------	.004	--------	.003	--------	.002	.002	--------	.002	.003	.004	--------	−.005	−.011	--------	--------
δ_{AF}	30°	--------	--------	--------	29°	--------	22°	--------	18°	16°	--------	14°	12°	8°	--------	−1°	−7°	--------	--------
AILERONS FLOATING, NEUTRAL—TRIANGULAR END PLATES																			
C_L	0°	−0.258	−0.009	0.087	0.263	0.580	0.863	0.956	1.047	1.103	1.098	1.075	1.043	0.960	0.638	0.630	0.620	0.579	0.500
C_D	0°	.045	.016	.016	.020	.040	.073	.090	.107	.127	.140	.156	.187	.213	.314	.389	.538	.694	.825
δ_{AF}	0°	15°	7°	0°	−5°	−10°	−15°	−17°	−19°	−21°	−21°	−22°	−25°	−24°	−22°	−29°	−34°	−41°	−48°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°	--------	--------	--------	0.032	--------	0.033	--------	0.033	0.033	--------	0.032	0.033	0.032	--------	0.037	0.024	--------	--------
C_n'	10°	--------	--------	--------	.001	--------	.003	--------	.003	.004	--------	.003	.003	.002	--------	−.005	−.006	--------	--------
δ_{AF}	10°	--------	--------	--------	9°	--------	−4°	--------	−9°	−11°	--------	−13°	−14°	−14°	--------	−20°	−29°	--------	--------
C_l'	20°	--------	--------	--------	.069	--------	.069	--------	.065	.064	--------	.062	.061	.069	--------	.071	.049	--------	--------
C_n'	20°	--------	--------	--------	.002	--------	.005	--------	.005	.005	--------	.004	.004	.002	--------	−.000	−.007	--------	--------
δ_{AF}	20°	--------	--------	--------	20°	--------	7°	--------	2°	1°	--------	0°	−2°	−4°	--------	−11°	−20°	--------	--------
C_l'	30°	--------	--------	--------	.098	--------	.090	--------	.086	.085	--------	.084	.079	.083	--------	.095	.074	--------	--------
C_n'	30°	--------	--------	--------	.004	--------	.004	--------	.004	.004	--------	.003	.003	.000	--------	−.003	−.010	--------	--------
δ_{AF}	30°	--------	--------	--------	30°	--------	20°	--------	16°	14°	--------	12°	10°	8°	--------	1°	−10°	--------	--------

TABLE VI

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°; 15 PER CENT AXIS

α	δ_A	−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS FLOATING, NEUTRAL—CIRCULAR END PLATES																	
C_L	0°	−0.253	0.004	0.123	0.289	0.567	0.789	0.821	0.885	0.945	0.960	0.972	0.985	0.920	0.634	0.640	0.638	0.592	0.500
C_D	0°	.106	.034	.083	.087	.104	.136	.144	.158	.176	.183	.195	.238	.273	.372	.421	.567	.724	.850
C_l'	0°	−.004	−.002	−.006	−.013	−.021	−.021	−.008	−.008	−.012	−.015	−.022	−.037	−.043	−.049	−.032	−.017	−.016	−.020
C_n'	0°	.003	.004	.003	.003	.003	.067	.010	.011	.013	.014	.014	.016	.017	.018	.019	.022	.026	.027
δ_{AF}	0°	10°	5°	2°	−2°	−7°	−13°	−15°	−17°	−19°	−19°	−20°	−22°	−23°	−24°	−30°	−49°	−58°	−66°
		RIGHT AILERON UP.—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.051	--------	0.072	--------	0.061	0.057	--------	0.059	0.074	0.073	--------	0.046	0.019	--------	--------
C_n'	20°	--------	--------	--------	.002	--------	.005	--------	.004	.002	--------	.004	.004	.004	--------	−.001	−.003	--------	--------
δ_{AF}	20°	--------	--------	--------	18°	--------	8°	--------	3°	2°	--------	−1°	−5°	−8°	--------	−9°	−12°	--------	--------
		AILERONS FLOATING, NEUTRAL—TRIANGULAR END PLATES																	
C_L	0°	−0.248	0.022	0.118	0.267	0.531	0.742	0.822	0.899	0.954	0.975	0.988	0.980	0.942	0.690	0.632	0.625	0.591	0.500
C_D	0°	.057	.035	.033	.036	.053	.076	.090	.104	.122	.132	.142	.177	.217	.333	.384	.529	.682	.817
C_l'	0°	.000	−.004	−.006	−.013	−.018	−.012	−.014	−.016	−.024	−.030	−.036	−.057	−.059	−.063	−.045	−.031	−.024	−.023
C_n'	0°	.004	.004	.005	.005	.006	.007	.008	.009	.011	.012	.013	.015	.016	.022	.024	.026	.031	.034
δ_{AF}	0°	12°	6°	2°	−2°	−9°	−13°	−15°	−17°	−19°	−20°	−21°	−23°	−27°	−33°	−38°	−47°	−56°	−63°
		RIGHT AILERON UP.—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.062	--------	0.049	--------	0.046	0.045	--------	0.069	0.070	0.072	--------	0.042	0.028	--------	--------
C_n'	20°	--------	--------	--------	.002	--------	.007	--------	.005	.006	--------	.002	.000	−.002	--------	−.006	−.007	--------	--------
δ_{AF}	20°	--------	--------	--------	20°	--------	6°	--------	3°	0°	--------	−1°	−2°	−3°	--------	−4°	−10°	--------	--------

TABLE VII

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

AILERONS FLOATING AND NEUTRAL—15 PER CENT AXIS

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation; $\frac{p'b}{2V}$ values are for free rotation

	α	0°	12°	14°	16°	18°	19°	20°	21°	22°	23°	24°	25°	30°	40°
		TRIANGULAR END PLATES													
(+) Rotation (clockwise)	C_λ	−0.021	−0.020	−0.017	−0.014	−0.002	--------	0.015	0.011	0.008	--------	−0.001	−0.002	−0.010	−0.007
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	0.209	.205	.206	--------	0.207	.048	.045	--------	--------
(−) Rotation (counter-clockwise)	C_λ	−.020	−.017	−.016	−.013	−.007	--------	.025	.007	.006	--------	.008	−.002	−.007	−.006
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	.172	.219	.201	--------	.133	.124	.120	--------	--------
		CIRCULAR END PLATES													
(+) Rotation (clockwise)	C_λ	−0.023	−0.021	−0.018	−0.013	0.002	0.008	0.014	0.011	0.005	--------	−0.001	−0.003	−0.012	−0.011
	$\frac{p'b}{2V}$	--------	--------	--------	--------	.118	.205	.207	.201	.196	0.040	.040	--------	--------	--------
(−) Rotation (counter-clockwise)	C_λ	−.021	−.017	−.014	−.008	−.002	.002	.017	.006	.008	--------	.007	−.003	−.006	−.007
	$\frac{p'b}{2V}$	--------	--------	--------	--------	--------	.181	.219	.194	.156	.118	.118	--------	--------	--------

TABLE VIII

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

AILERONS FLOATING AND NEUTRAL—15 PER CENT AXIS

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation

	α	0°	5°	8°	9°	12°	14°	16°	18°	20°	22°	23°	25°	30°	40°
		TRIANGULAR END PLATES													
(−) Rotation (counter-clockwise)	C_λ	−0.010	--------	--------	--------	−0.002	0.003	0.010	0.024	0.041	0.062	0.057	0.047	0.028	0.017
(+) Rotation (clockwise)	C_λ	−.035	--------	--------	--------	−.037	−.041	−.047	−.057	−.067	−.073	−.069	−.063	−.045	−.034
		CIRCULAR END PLATES													
(−) Rotation (counter-clockwise)	C_λ	−0.011	0.002	0.005	−0.008	−0.008	−0.006	0.000	0.009	0.034	0.042	0.047	0.041	0.014	0.007
(+) Rotation (clockwise)	C_λ	−.034	−.025	--------	--------	−.023	−.024	−.027	−.031	−.039	−.052	−.049	−.041	−.034	−.022

TABLE IX

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT *c* BY 20 PER CENT *b*/2; FLAPS UP 2°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

α		−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.224	0.027	0.098	0.267	0.571	0.854	0.957	1.040	1.090	1.082	1.070	1.047	0.957	0.679	0.655	0.625	0.575	0.500
C_D	0°	.047	.016	.016	.021	.041	.072	.091	.111	.132	.147	.161	.191	.221	.323	.400	.552	.697	.832
δ_{AF}	0°	17°	7°	1°	−5°	−10°	−15°	−16°	−18°	−18°	−19°	−20°	−21°	−22°	−23°	−28°	−38°	−48°	−50°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	10°	--------	--------	--------	0.035	--------	0.038	--------	0.039	--------	0.038	--------	0.037	0.035	0.036	0.034	0.025	--------	--------
C_n'	10°	--------	--------	--------	.001	--------	.003	--------	.004	--------	.004	--------	.003	.002	−.003	−.005	−.006	--------	--------
δ_{AF}	10°	--------	--------	--------	9°	--------	−4°	--------	−8°	--------	−11°	--------	−12°	−14°	−17°	−22°	−30°	--------	--------
C_l'	20°	--------	--------	--------	.070	--------	.069	--------	.070	--------	.070	--------	.070	.073	.068	.065	.051	--------	--------
C_n'	20°	--------	--------	--------	−.001	--------	.003	--------	.004	--------	.005	--------	.005	.002	−.006	−.005	−.008	--------	--------
δ_{AF}	20°	--------	--------	--------	20°	--------	7°	--------	1°	--------	−2°	--------	−4°	−5°	−8°	−13°	−22°	--------	--------
C_l'	30°	--------	--------	--------	.100	--------	.085	--------	.080	--------	.072	--------	.066	.075	.086	.087	.071	--------	--------
C_n'	30°	--------	--------	--------	.000	--------	.001	--------	.002	--------	.001	--------	−.001	−.003	−.004	−.003	−.008	--------	--------
δ_{AF}	30°	--------	--------	--------	27°	--------	17°	--------	14°	--------	11°	--------	10°	8°	0°	−6°	−10°	--------	--------
		AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																	
C_L	0°	−0.193	0.068	0.106	0.268	0.574	0.874	0.978	1.062	1.115	1.100	1.092	1.063	0.975	0.700	0.650	0.635	0.590	0.502
C_D	0°	.044	.019	.018 .016	.021	.041	.073	.090	.106	.129	.144	.160	.190	.220	.326	.399	.552	.702	.830
δ_{AF}	0°	21°	13°	0° −1°	−5°	−8°	−13°	−12°	−14°	−15°	−16°	−17°	−19°	−18°	−19°	−24°	−35°	−42°	−52°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	10°	--------	--------	--------	0.034	--------	0.037	--------	0.037	--------	0.037	--------	0.037	0.036	0.036	0.034	0.025	--------	--------
C_n'	10°	--------	--------	--------	.000	--------	.002	--------	.002	--------	.002	--------	.002	.000	−.005	−.005	−.007	--------	--------
δ_{AF}	10°	--------	--------	--------	10°	--------	−2°	--------	−6°	--------	−8°	--------	−11°	−10°	−13°	−19°	−29°	--------	--------
C_l'	20°	--------	--------	--------	.072	--------	.073	--------	.072	--------	.072	--------	.072	.078	.068	.065	.049		
C_n'	20°	--------	--------	--------	.000	--------	.002	--------	.003	--------	.003	--------	.003	.000	−.008	−.007	−.009		
δ_{AF}	20°	--------	--------	--------	21°	--------	8°	--------	3°	--------	0°	--------	−3°	−3°	−6°	−12°	−22°	--------	--------
C_l'	30°	--------	--------	--------	.103	--------	.083	--------	.075	--------	.068	--------	.061	.072	.077	.081	.070		
C_n'	30°	--------	--------	--------	.000	--------	−.001	--------	−.001	--------	−.001	--------	−.002	−.003	−.006	−.007	−.011	--------	--------
δ_{AF}	30°	--------	--------	--------	30°	--------	20°	--------	17°	--------	15°	--------	13°	12°	5°	−2°	−11°	--------	--------
		AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																	
C_L	0°	−.170	0.116 .100	0.230 .051	0.245 .239	0.575	0.898	1.000	1.098	1.180	1.120	1.110	1.085	0.985	0.713	0.656	0.645	0.605	0.520
C_D	0°	.042	.024 .023	.023 .019	.024 .022	.041	.073	.089	.105	.129	.143	.159	.189	.220	.331	.402	.562	.707	.846
δ_{AF}	0°	24°	19° 17°	15° −4°	−6°	−9°	−9°	−10°	−11°	−13°	−13°	−14°	−14°	−15°	−17°	−24°	−32°	−38°	−46°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	10°	--------	--------	--------	0.035	--------	0.036	--------	0.036	--------	0.036	--------	0.033	0.036	0.035	0.033	0.024	--------	--------
C_n'	10°	--------	--------	--------	−.001	--------	.001	--------	.001	--------	.001	--------	.000	−.002	−.006	−.005	−.007	--------	--------
δ_{AF}	10°	--------	--------	--------	11°	--------	−1°	--------	−4°	--------	−6°	--------	−7°	−9°	−12°	−19°	−28°	--------	--------
C_l'	20°	--------	--------	--------	.073	--------	--------	--------	--------	--------	.070	--------	.078	.077	.068	.064	.048	--------	--------
C_n'	20°	--------	--------	--------	.001	--------	--------	--------	--------	--------	.003	--------	.003	−.000	−.007	−.006	−.010	--------	--------
δ_{AF}	20°	--------	--------	--------	21°	--------	--------	--------	--------	--------	1°	--------	−2°	−3°	−5°	−12°	−20°	--------	--------
C_l'	30°	--------	--------	--------	.104	--------	.086	--------	.078	--------	.070	--------	.070	.074	.078	.087	.069	--------	--------
C_n'	30°	--------	--------	--------	.001	--------	.001	--------	.000	--------	.000	--------	.000	−.003	−.006	−.007	−.011	--------	--------
δ_{AF}	30°	--------	--------	--------	30°	--------	21°	--------	18°	--------	16°	--------	14°	12°	5°	0°	−9°	--------	--------

TABLE X

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 2°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

α		−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.217	0.022	0.108	0.249	0.518	0.765	0.850	0.927	0.994	1.007	1.019	1.045	1.009	0.715	0.652	0.638	0.590	0.495
C_D	0°	.034	.018	.017	.022	.041	.071	.087	.104	.120	.129	.141	.179	.219	.336	.386	.538	.683	.804
C_l'	0°	.009	.003	−.002	−.009	−.016	−.021	−.023	−.027	−.035	−.039	−.045	−.065	−.066	−.074	−.044	−.029	−.025	−.022
C_n'	0°	.001	.001	.001	.001	.002	.003	.004	.006	.008	.010	.011	.012	.014	.024	.025	.027	.032	.034
δ_{AF}	0°	13°	5°	1°	−5°	−10°	−16°	−18°	−20°	−21°	−21°	−22°	−25°	−25°	−30°	−35°	−45°	−55°	−65°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	-------	-------	-------	0.063	-------	0.069	-------	0.072	-------	0.066	-------	0.062	0.060	0.041	0.039	0.028	-------	-------
C_n'	20°	-------	-------	-------	−.003	-------	−.008	-------	−.014	-------	−.021	-------	−.002	−.004	−.007	−.008	−.007	-------	-------
δ_{AF}	20°	-------	-------	-------	21°	-------	7°	-------	2°	-------	0°	-------	0°	−2°	−3°	−5°	−14°	-------	-------
		AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																	
C_L	0°	−0.204	0.041	0.113	0.255	0.519	0.777	0.863	0.944	1.008	1.025	1.039	1.050	1.009	0.722	0.650	0.638	0.602	0.497
C_D	0°	.034	.017	.018	.021	.040	.070	.084	.100	.118	.125	.139	.177	.219	.338	.389	.533	.691	.807
C_l'	0°	.010	.004	−.002	−.009	−.015	−.019	−.022	−.026	−.034	−.039	−.047	−.066	−.067	−.075	−.044	−.030	−.026	−.026
C_n'	0°	.000	.001	.001	.001	.002	.003	.005	.006	.008	.010	.010	.013	.015	.023	.024	.026	.031	.033
δ_{AF}	0°	16°	8°	2°	−4°	−10°	−15°	−17°	−18°	−20°	−21°	−22°	−23°	−25°	−28°	−33°	−46°	−55°	−62°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	-------	-------	-------	0.065	-------	0.069	-------	0.059	-------	0.062	-------	0.062	0.056	0.039	0.034	0.027	-------	-------
C_n'	20°	-------	-------	-------	−.005	-------	−.004	-------	−003	-------	−.003	-------	−.004	−.006	−.009	−.008	−.009	-------	-------
δ_{AF}	20°	-------	-------	-------	25°	-------	12°	-------	5°	-------	4°	-------	3°	1°	0°	−2°	−9°	-------	-------
		AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																	
C_L	0°	−0.200	0.050	0.118	0.257	0.524	0.779	0.879	0.952	1.005	1.033	1.050	1.054	1.017	0.719	0.655	0.626	0.591	0.503
C_D	0°	.033	.018	.016	.021	.039	.069	.082	.097	.116	.124	.138	.173	.217	.336	.390	.537	.692	.812
C_l'	0°	.010	.005	−.001	−.009	−.013	−.018	−.021	−.025	−.033	−.037	−.046	−.060	−.066	−.076	−.046	−.030	− .026	−.027
C_n'	0°	.003	.001	.001	.001	.002	.004	.005	.006	.008	.010	.010	.012	.015	.024	.025	.026	.031	.035
δ_{AF}	0°	17°	10°	2°	−3°	−9°	−13°	−14°	−16°	−18°	−18°	−19°	−20°	−22°	−27°	−33°	−45°	−55°	−61°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	-------	-------	-------	0.065	-------	-------	-------	0.067	-------	0.062	-------	0.062	0.056	0.040	0.032	0.023	-------	-------
C_n'	20°	-------	-------	-------	.003	-------	-------	-------	−.001	-------	−.001	-------	−.004	−.006	−.010	−.008	−.008	-------	-------
δ_{AF}	20°	-------	-------	-------	25°	-------	-------	-------	4°	-------	2°	-------	3°	1°	4°	0°	−10°	-------	-------

TABLE XI

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 2°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation; $\frac{p'b}{2V}$ values are for free autorotation

	α	0°	12°	14°	16°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	30°	40°
		10 per cent axis																
(+) Rotation (clockwise).	C_λ	−0.022	−0.019	−0.017	−0.014	−0.002	------	0.014	------	0.018	------	------	−0.013	------	------	------	−0.010	−0.008
	$\frac{p'b}{2V}$	------	------	------	------	------	0.108	.120	0.140	.149	0.165	------	------	------	------	------	------	------
(−) Rotation (counterclockwise).	C_λ	−.020	−.017	−.016	−.013	−.008	------	−.029	------	.004	------	------	.005	------	------	------	−.004	−.006
	$\frac{p'b}{2V}$	------	------	------	------	------	------	------	.157	.061	------	------	.072	0.068	0.060	0.032	------	------
		15 per cent axis																
(+) Rotation (clockwise).	C_λ	−0.022	−0.020	−0.018	−0.013	−0.001	------	0.014	------	0.018	------	------	−0.013	------	------	------	−0.009	−0.007
	$\frac{p'b}{2V}$	------	------	------	------	------	0.115	.121	0.140	.154	0.174	------	------	------	------	------	------	------
(−) Rotation (counterclockwise).	C_λ	−.019	−.017	−.016	−.013	−.007	------	−.029	------	.003	------	------	.004	------	------	------	−.004	−.006
	$\frac{p'b}{2V}$	------	------	------	------	------	------	------	.076	.059	.073	0.073	------	------	0.059	0.030	------	------
		20 per cent axis																
(+) Rotation (clockwise).	C_λ	−0.022	−0.020	−0.018	−0.014	0.000	------	0.015	------	0.020	------	------	−0.010	------	------	------	−0.008	−0.005
	$\frac{p'b}{2V}$	------	------	------	------	------	0.113	.120	0.140	.160	0.180	------	------	------	------	------	------	------
(−) Rotation (counterclockwise).	C_λ	−.021	−.017	−.016	−.014	−.006	------	−.030	------	.000	------	------	.003	------	------	------	−.004	−.006
	$\frac{p'b}{2V}$	------	------	------	------	------	------	------	.038	.040	.064	0.071	------	0.060	0.034	0.035	------	------

TABLE XII

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT b/2; FLAPS UP 2°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation

	α	0°	12°	14°	16°	18°	20°	22°	25°	30°	40°
						10 per cent axis					
(−) Rotation (counterclockwise)	C_λ	−0.014	0.007	0.011	0.018	0.028	0.045	0.064	0.052	0.029	0.017
(+) Rotation (clockwise)	C_λ	−.029	−.043	−.046	−.053	−.062	−.071	−.068	−.060	−.043	−.034
						15 per cent axis					
(−) Rotation (counterclockwise)	C_λ	−0.016	0.005	0.010	0.017	0.028	0.045	0.061	0.053	0.030	0.018
(+) Rotation (clockwise)	C_λ	−.028	−.043	−.046	−.051	−.061	−.070	−.068	−.061	−.044	−.034
						20 per cent axis					
(−) Rotation (counterclockwise)	C_λ	−0.017	0.003	0.009	0.013	0.027	0.046	0.065	0.053	0.031	0.017
(+) Rotation (clockwise)	C_λ	−.031	−.042	−.045	−.050	−.060	−.069	−.068	−.061	−.044	−.033

TABLE XIII

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT b/2; FLAPS UP 2°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

α		−10°	5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.236	0.037	0.145	0.310	0.611	0.884	0.978	1.059	1.095	1.084	1.068	1.040	0.944	0.777	0.662	0.618	0.572	0.493
C_D	0°	.044	.018	.017	.021	.041	.076	.094	.111	.132	.149	.164	.194	.222	.317	.408	.546	.697	.837
δ_{AF}	0°	16°	9°	4°	2°	−8°	−15°	−17°	−19°	−21°	−22°	−23°	−25°	−26°	−26°	−30°	−35°	−43°	−53°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	10°	-----	-----	-----	0.032	-----	0.033	-----	0.031	-----	0.031	-----	0.031	0.028	0.024	0.041	0.034	-----	-----
C_n'	10°	-----	-----	-----	.001	-----	.003	-----	.003	-----	.003	-----	.003	.003	.002	−.007	−.006	-----	-----
δ_{AF}	10°	-----	-----	-----	10°	-----	−5°	-----	−9°	-----	−11°	-----	−13°	−15°	−15°	−20°	−25°	-----	-----
C_l'	20°	-----	-----	-----	.067	-----	.065	-----	.062	-----	.060	-----	.069	.063	.080	.073	.049	-----	-----
C_n'	20°	-----	-----	-----	.000	-----	.004	-----	.004	-----	.004	-----	.003	.001	−.005	−.009	−.003	-----	-----
δ_{AF}	20°	-----	-----	-----	20°	-----	6°	-----	2°	-----	−1°	-----	−4°	−5°	−8°	−13°	−21°	-----	-----
C_l'	30°	-----	-----	-----	.096	-----	.088	-----	.083	-----	.082	-----	.087	.080	.095	.098	.074	-----	-----
C_n'	30°	-----	-----	-----	.001	-----	.002	-----	.003	-----	.002	-----	.002	−.001	−.002	−.008	−.009	-----	-----
δ_{AF}	30°	-----	-----	-----	30°	-----	20°	-----	16°	-----	13°	-----	10°	9°	3°	−2°	−11°	-----	-----
		AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																	
C_L	0°	−0.217	0.062	0.166	0.313	0.618	0.905	1.002	1.083	1.125	1.114	1.098	1.055	0.968	0.690	0.640	0.627	0.585	0.500
C_D	0°	.053	.019	.017	.021	.040	.073	.089	.109	.130	.144	.160	.190	.218	.323	.392	.550	.704	.837
δ_{AF}	0°	18°	13°	8°	−1°	−6°	−11°	−13°	−15°	−17°	−18°	−19°	−21°	−21°	−20°	−27°	−33°	−39°	−47°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	10°	-----	-----	-----	0.033	-----	0.034	-----	0.032	-----	0.032	-----	0.019	0.031	0.027	0.038	0.027	-----	-----
C_n'	10°	-----	-----	-----	.000	-----	.001	-----	.002	-----	.003	-----	.002	.001	−.004	−.006	−.007	-----	-----
δ_{AF}	10°	-----	-----	-----	11°	-----	−3°	-----	−7°	-----	−10°	-----	−12°	−13°	−14°	−19°	−26°	-----	-----
C_l'	20°	-----	-----	-----	.069	-----	.067	-----	.062	-----	.060	-----	.059	.069	.065	.072	.050	-----	-----
C_n'	20°	-----	-----	-----	.000	-----	.003	-----	.003	-----	.003	-----	.002	.001	−.006	−.008	−.009	-----	-----
δ_{AF}	20°	-----	-----	-----	20°	-----	7°	-----	3°	-----	0°	-----	−3°	−5°	−8°	−11°	−20°	-----	-----
C_l'	30°	-----	-----	-----	.098	-----	.087	-----	.080	-----	.077	-----	.072	.082	.091	.097	.074	-----	-----
C_n'	30°	-----	-----	-----	.002	-----	.002	-----	.002	-----	.002	-----	.000	−.003	−.005	−.010	−.011	-----	-----
δ_{AF}	30°	-----	-----	-----	29°	-----	19°	-----	15°	-----	13°	-----	11°	10°	3°	0°	−10°	-----	-----
		AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																	
C_L	0°	−0.197	0.100	0.225 .090	0.396	0.675	0.948	1.045	1.123	1.158	1.150	1.140	1.098	0.999	0.703	0.643	0.638	0.602	0.520
C_D	0°	.046	.024	.023 .018	.024	.042	.075	.090	.109	.130	.145	.160	.191	.222	.325	.400	.552	.712	.843
δ_{AF}	0°	21°	16°	13° −2°	9°	−1°	−6°	−8°	−10°	−12°	−13°	−13°	−15°	−16°	−17°	−26°	−30°	−35°	−44°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	10°	-----	-----	-----	0.032	-----	0.033	-----	0.033	-----	0.030	-----	0.023	0.030	0.031	0.036	0.025	-----	-----
C_n'	10°	-----	-----	-----	.000	-----	.001	-----	.001	-----	.001	-----	.001	.000	−.005	−.006	−.006	-----	-----
δ_{AF}	10°	-----	-----	-----	13°	-----	0°	-----	−4°	-----	−7°	-----	−11°	−12°	−14°	−18°	−25°	-----	-----
C_l'	20°	-----	-----	-----	.070	-----	-----	-----	-----	-----	.058	-----	.061	068	.066	.071	.050	-----	-----
C_n'	20°	-----	-----	-----	.000	-----	-----	-----	-----	-----	.003	-----	.002	.002	−.006	−.008	−.009	-----	-----
δ_{AF}	20°	-----	-----	-----	21°	-----	-----	-----	-----	-----	0°	-----	−2°	−4°	−5°	−10°	−19°	-----	-----
C_l'	30°	-----	-----	-----	.098	-----	.089	-----	.083	-----	.079	-----	.074	.079	.088	.094	.073	-----	-----
C_n'	30°	-----	-----	-----	.006	-----	.004	-----	.005	-----	.005	-----	.003	.000	−.004	−.011	−.013	-----	-----
δ_{AF}	30°	-----	-----	-----	28°	-----	18°	-----	16°	-----	13°	-----	11°	10°	4°	1°	−8°	-----	-----

TABLE XIV

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 2°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

α	δ_A	−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
AILERONS FLOATING NEUTRAL—10 PER CENT AXIS																			
C_L	0°	−0.236	0.033	0.133	0.284	0.536	0.744	0.829	0.899	0.950	0.970	0.973	0.848	0.765	0.748	0.622	0.618	0.578	0.496
C_D	0°	.056	.037	.036	.037	.053	.077	.091	.109	.126	.136	.147	.153	.187	.328	.382	.530	.680	.807
C_l'	0°	−.001	−.003	−.006	−.012	−.018	−.012	−.015	−.019	−.028	−.033	−.040	−.059	−.070	−.070	−.038	−.029	−.023	−.022
C_n'	0°	.004	.004	.005	.005	.006	.007	.008	.010	.012	.013	.014	.013	.016	.017	.020	.025	.029	.032
δ_{AF}	0°	12°	7°	2°	−2°	−9°	−13°	−15°	−17°	−19°	−20°	−22°	−25°	−27°	−33°	−37°	−47°	−57°	−64°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	20°	--------	--------	--------	0.056	--------	0.045	--------	0.056	--------	0.047	--------	0.075	0.074	0.062	0.043	0.028	--------	--------
C_n'	20°	--------	--------	--------	.000	--------	−.005	--------	.004	--------	.005	--------	.002	−.001	.003	−.005	−.006	--------	--------
δ_{AF}	20°	--------	--------	--------	20°	--------	5°	--------	1°	--------	−2°	--------	−4°	−3°	−4°	−6°	−12°	--------	--------
AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																			
C_L	0°	−0.245	0.037	0.138	0.284	0.545	0.760	0.848	0.918	0.965	0.984	0.996	0.852	0.745	.690	0.627	0.622	0.583	0.496
C_D	0°	.056	.035	.035	.036	.053	.075	.089	.016	.123	.132	.143	.249	.289	.334	.385	.532	.677	.812
C_l'	0°	0	−.003	−.005	−.011	−.017	−.010	−.013	−.017	−.025	−.030	−.037	−.063	−.061	−.076	−.044	−.030	−.024	−.024
C_n'	0°	−.001	.004	.005	.005	.006	.007	.008	.009	.012	.013	.014	.016	.017	.022	.022	.025	.030	.033
δ_{AF}	0°	11°	7°	3°	−1°	−7°	−11°	−13°	−15°	−17°	−18°	−19°	−22°	−25°	−32°	−37°	−47°	−56°	−62°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	20°	--------	--------	--------	0.060	--------	0.046	--------	0.044	--------	0.043	--------	.071	0.071	0.051	0.041	0.027	--------	--------
C_n'	20°	--------	--------	--------	.000	--------	.006	--------	.004	--------	.005	--------	.000	−.004	−.003	−.005	−.007	--------	--------
δ_{AF}	20°	--------	--------	--------	21°	--------	6°	--------	2°	--------	−2°	--------	−2°	−2°	−2°	−5°	−9°	--------	--------
AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																			
C_L	0°	−0.245	0.048	0.156	0.289	0.552	0.803	0.864	0.938	0.990	1.013	1.014	1.006	0.963	0.672	0.630	0.618	0.585	0.560
C_D	0°	.057	.038	.038	.038	.054	.081	.090	.104	.120	.129	.142	.175	.219	.335	.390	.534	.688	.815
C_l'	0°	−.001	−.002	−.003	−.010	−.015	−.016	−.008	−.012	−.020	−.024	−.032	−.048	−.052	−.080	−.048	−.030	−.024	−.024
C_n'	0°	.002	.003	.004	.005	.006	.007	.007	.009	.011	.012	.014	.015	.017	.023	.024	.026	.031	.033
δ_{AF}	0°	11°	8°	6°	3°	−6°	−10°	−11°	−12°	−14°	−14°	−15°	−18°	−19°	−32°	−37°	−48°	−57°	−62°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	20°	--------	--------	--------	0.058	--------	0.050	--------	0.036	--------	0.058	--------	0.059	0.060	0.054	0.038	0.025	--------	--------
C_n'	20°	--------	--------	--------	−.005	--------	.005	--------	.005	--------	.003	--------	.000	−.005	−.004	−.006	−.008	--------	--------
δ_{AF}	20°	--------	--------	--------	24°	--------	6°	--------	2°	--------	−2°	--------	−2°	−2°	−2°	−5°	−10°	--------	--------

TABLE XV

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; WITH FLAPS UP 2°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation; $\frac{p'b}{2V}$ values are for free autorotation

	α	0°	12°	14°	16°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	30°	40°
10 per cent axis																		
(+) Rotation (clockwise).	C_λ	−0.021	−0.018	−0.017	−0.013	0.000	-------	0.018	-------	0.022	-------	-------	−0.008	-------	-------	-------	−0.009	−0.007
	$\frac{p'b}{2V}$	-------	-------	-------	-------	.099	0.138	.150	0.196	.216	0.234	-------	-------	-------	-------	-------	-------	-------
(−) Rotation (counterclockwise).	C_λ	−.019	−.018	−.016	−.014	−.007	-------	−.031	-------	.005	-------	-------	.008	-------	-------	-------	−.007	−.007
	$\frac{p'b}{2V}$	-------	-------	-------	-------	-------	-------	.234	-.206	.163	.118	0.114	-------	0.096	-------	0.39	-------	-------
15 per cent axis																		
(+) Rotation (clockwise).	C_λ	−0.021	−0.018	−0.017	−0.013	0.000	-------	0.018	-------	0.020	-------	-------	−0.010	-------	-------	-------	−0.009	−0.007
	$\frac{p'b}{2V}$	-------	-------	-------	-------	.133	0.133	.159	0.186	.225	0.230	-------	-------	-------	-------	-------	-------	-------
(−) Rotation (counterclockwise).	C_λ	−.020	−.017	−.015	−.013	−.006	-------	−.031	-------	.006	-------	-------	.007	-------	-------	-------	−.005	−.005
	$\frac{p'b}{2V}$	-------	-------	-------	-------	-------	-------	.235	.208	.159	.109	0.111	-------	0.093	-------	0.036	-------	-------
20 per cent axis																		
(+) Rotation (clockwise).	C_λ	−0.023	−0.018	−0.017	−0.013	0.002	-------	0.016	-------	0.019	-------	-------	−0.011	-------	-------	-------	−0.008	−0.006
	$\frac{p'b}{2V}$	-------	-------	-------	-------	.092	0.139	.154	0.175	.223	-------	-------	-------	-------	-------	-------	-------	-------
(−) Rotation (counterclockwise).	C_λ	−.021	−.019	−.017	−.012	−.006	-------	−.030	-------	.005	-------	-------	.006	-------	-------	-------	−.004	−.006
	$\frac{p'b}{2V}$	-------	-------	-------	-------	-------	-------	-------	.201	.109	0.102	-------	.096	0.081	0.077	0.035	-------	-------

TABLE XVI

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH SYMMETRICAL TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 2°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}$=0.05, (+) aiding rotation, (−) damping rotation

	α	0°	12°	14°	16°	18°	20°	22°	25°	30°	40°
10 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.011	−0.001	0.004	0.012	0.026	0.042	0.057	0.046	0.028	0.018
(+) Rotation (clockwise)	C_λ	−.034	−.037	−.041	−.046	−.056	−.064	−.073	−.064	−.045	−.036
15 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.012	−0.005	0.000	0.007	0.021	0.037	0.061	0.046	0.027	0.017
(+) Rotation (clockwise)	C_λ	−.033	−.034	−.038	−.043	−.052	−.061	−.069	−.062	−.045	−.035
20 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.015	−0.006	−0.004	0.003	0.017	0.033	0.056	0.057	0.032	0.016
(+) Rotation (clockwise)	C_λ	−.031	−.030	−.033	−.037	−.046	−.056	−.067	−.066	−.048	−.034

TABLE XVII

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°

R. N.=609,000; VELOCITY= 80 M. P. H.; YAW=0°

α	δ_A	−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																			
C_L	0°	−0.223	0.025	0.115	0.274	0.572	0.859	0.970	1.052	1.093	1.091	1.076	1.044	0.950	0.688	0.650	0.631	0.582	0.488
C_D	0°	.044	.017	.017	.022	.042	.075	.091	.111	.131	.146	.162	.192	.222	.326	.402	.555	.704	.830
δ_{AF}	0°	18°	8°	2°	−6°	−11°	−16°	−16°	−17°	−19°	−20°	−20°	−21°	−22°	−22°	−28°	−37°	−46°	−54°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°	--------	--------	--------	0.034	--------	0.037	--------	0.039	--------	0.037	--------	0.036	0.034	0.035	0.038	0.025	--------	--------
C_n'	10°	--------	--------	--------	.001	--------	.003	--------	.004	--------	.004	--------	.003	.002	−.003	−.006	−.007	--------	--------
δ_{AF}	10°	--------	--------	--------	9°	--------	−4°	--------	−7°	--------	−10°	--------	−11°	−13°	−16°	−19°	−29°	--------	--------
C_l'	20°	--------	--------	--------	.070	--------	.077	--------	.077	--------	.075	--------	.075	.074	.077	.065	.045	--------	--------
C_n'	20°	--------	--------	--------	.001	--------	.005	--------	.007	--------	.008	--------	.007	.005	−.001	−.005	−.007	--------	--------
δ_{AF}	20°	--------	--------	--------	21°	--------	8°	--------	4°	--------	1°	--------	−2°	−4°	−7°	−12°	−21°	--------	--------
C_l'	30°	--------	--------	--------	.099	--------	.102	--------	.103	--------	.097	--------	.089	.086	.101	.087	.067	--------	--------
C_n'	30°	--------	--------	--------	−.003	--------	.004	--------	.006	--------	.008	--------	.009	.008	−.001	−.003	−.006	--------	--------
δ_{AF}	30°	--------	--------	--------	34°	--------	22°	--------	18°	--------	15°	--------	13°	10°	7°	2°	−9°	--------	--------
AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																			
C_L	0°	−0.203	0.063	0.096	0.261	0.574	0.872	0.978	1.062	1.118	1.099	1.085	1.055	0.973	0.696	0.651	0.635	0.587	0.503
C_D	0°	.044	.019	.018	.023	.044	.077	.092	.109	.131	.148	.162	.194	.222	.330	.402	.559	.710	.841
δ_{AF}	0°	20°	10°	−2°	−6°	−11°	−15°	−15°	−16°	−18°	−19°	−19°	−20°	−20°	−21°	−28°	−36°	−43°	−51°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°	--------	--------	--------	0.035	--------	0.037	--------	0.038	--------	0.038	--------	0.037	0.036	0.036	0.037	0.025	--------	--------
C_n'	10°	--------	--------	--------	.000	--------	.002	--------	.003	--------	.003	--------	.002	.000	−.003	−.006	−.007	--------	--------
δ_{AF}	10°	--------	--------	--------	9°	--------	−4°	--------	−7°	--------	−9°	--------	−11°	−12°	−14°	−20°	−29°	--------	--------
C_l'	20°	--------	--------	--------	.071	--------	.076	--------	.077	--------	.075	--------	.075	.073	.078	.065	.047	--------	--------
C_n'	20°	--------	--------	--------	.000	--------	.003	--------	.005	--------	.006	--------	.006	.004	−.002	−.006	−.008	--------	--------
δ_{AF}	20°	--------	--------	--------	22°	--------	10°	--------	5°	--------	2°	--------	0°	−2°	−6°	−11°	−20°	--------	--------
C_l'	30°	--------	--------	--------	.100	--------	.085	--------	.083	--------	.081	--------	.073	{.059 .068}	.092	.088	.068	--------	--------
C_n'	30°	--------	--------	--------	−.003	--------	.001	--------	.002	--------	.003	--------	.003	.002	−.003	−.001	−.006	--------	--------
δ_{AF}	30°	--------	--------	--------	33°	--------	23°	--------	19°	--------	16°	--------	13°	11°	9°	−1°	−10°	--------	--------
AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																			
C_L	0°	−0.173	0.109	0.222	0.237	0.564	0.883	1.003	1.008	1.129	1.122	1.112	1.086	1.003	0.712	0.657	0.644	0.608	0.514
C_D	0°	.046	.024	.022	.023	.042	.074	.089	.106	.131	.145	.162	.191	.224	.337	.407	.560	.711	.842
δ_{AF}	0°	22°	16°	14°	−9°	−11°	−13°	−14°	−15°	−16°	−17°	−18°	−18°	−18°	−20°	−28°	−33°	−40°	−49°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°	--------	--------	--------	0.034	--------	0.036	--------	0.037	--------	0.037	--------	0.038	0.036	0.035	0.035	0.024	--------	--------
C_n'	10°	--------	--------	--------	.000	--------	.002	--------	.002	--------	.001	--------	.000	−.002	−.005	−.006	−.007	--------	--------
δ_{AF}	10°	--------	--------	--------	9°	--------	−3°	--------	−6°	--------	−8°	--------	−10°	−10°	−14°	−20°	−29°	--------	--------
C_l'	20°	--------	--------	--------	.071	--------	.075	--------	.074	--------	.075	--------	.075	.069	.078	.064	.047	--------	--------
C_n'	20°	--------	--------	--------	−.001	--------	.002	--------	.004	--------	.004	--------	.004	.002	−.002	−.006	−.008	--------	--------
δ_{AF}	20°	--------	--------	--------	22°	--------	10°	--------	5°	--------	3°	--------	0°	−1°	−6°	−11°	−21°	--------	--------
C_l'	30°	--------	--------	--------	.102	--------	.085	--------	.083	--------	.080	--------	.072	.057	.091	.086	.068	--------	--------
C_n'	30°	--------	--------	--------	−.003	--------	.001	--------	.002	--------	.001	--------	.001	.002	−.004	−.001	−.007	--------	--------
δ_{AF}	30°	--------	--------	--------	32°	--------	21°	--------	17°	--------	14°	--------	12°	11°	8°	−2°	−10°	--------	--------

TABLE XVIII

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

α		−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
	δ_A	AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.209	0.034	0.126	0.254	0.512	0.761	0.853	0.920	0.984	1.003	1.016	1.038	1.032	0.751	0.670	0.639	0.592	0.503
C_D	0°	.035	.021	.019	.022	.041	.071	.086	.100	.118	.127	.137	.176	.218	.340	.406	.545	.697	.817
C_l'	0°	.010	.004	−.000	−.007	−.016	−.022	−.025	−.029	−.036	−.040	−.046	−.060	−.086	−.065	−.046	−.031	−.026	−.025
C_n'	0°	.001	.002	.001	.002	.002	.004	.005	.006	.008	.010	.010	.012	.015	.024	.026	.026	.031	.034
δ_{AF}	0°	19°	11°	7°	−2°	−9°	−14°	−16°	−17°	−19°	−19°	−20°	−23°	−24°	−27°	−33°	−44°	−46°	−53°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	20°	----	----	----	0.069	----	0.071	----	0.071	----	0.071	----	0.065	0.060	0.043	0.038	0.028	----	----
C_n'	20°	----	----	----	−.001	----	.000	----	.000	----	−.001	----	−.002	−.002	−.005	−.006	−.005	----	----
δ_{AF}	20°	----	----	----	22°	----	9°	----	5°	----	3°	----	1°	−1°	0°	−5°	−12°	----	----
AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																			
C_L	0°	−0.204	0.049	0.152	0.260	0.518	0.765	0.864	0.945	0.988	1.020	1.034	1.047	1.045	0.756	0.668	0.664	0.606	0.505
C_D	0°	.037	.022	.021	.022	.041	.070	.086	.099	.117	.125	.138	.175	.218	.340	.408	.547	.704	.830
C_l'	0°	.011	.006	.003	−.007	−.014	−.021	−.024	−.026	−.034	−.039	−.045	−.058	−.086	−.065	−.047	−.030	−.027	−.028
C_n'	0°	.001	.001	.002	.001	.002	.004	.005	.006	.008	.010	.011	.012	.015	.025	.026	.026	.030	.035
δ_{AF}	0°	19°	13°	9°	−1°	−8°	−13°	−15°	−16°	−17°	−18°	−19°	−21°	−23°	−28°	−33°	−45°	−55°	−61°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	20°	----	----	----	0.070	----	0.071	----	0.069	----	0.070	----	0.065	0.059	0.044	0.036	0.027	----	----
C_n'	20°	----	----	----	−.003	----	−.001	----	−.001	----	−.003	----	−.003	−.004	−.006	−.006	−.007	----	----
δ_{AF}	20°	----	----	----	23°	----	10°	----	6°	----	5°	----	3°	3°	3°	−2°	−11°	----	----
AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																			
C_L	0°	−0.199	0.050	0.147	0.262	0.506	0.787	0.882	0.953	1.011	1.022	1.043	1.054	1.047	0.752	0.680	0.640	0.595	0.503
C_D	0°	.036	.022	.021	.022	.040	.070	.084	.099	.116	.124	.138	.171	.216	.343	.410	.552	.712	.830
C_l'	0°	.009	.003	.000	−.006	−.015	−.020	−.029	−.027	−.034	−.038	−.046	−.060	−.087	−.065	−.049	−.028	−.025	−.028
C_n'	0°	.001	.002	.001	.001	.002	.004	.005	.007	.008	.010	.011	.012	.015	.024	.027	.026	.030	.034
δ_{AF}	0°	18°	12°	8°	−1°	−9°	−13°	−14°	−15°	−17°	−18°	−19°	−21°	−23°	−28°	−35°	−47°	−53°	−64°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	20°	----	----	----	0.070	----	0.070	----	0.070	----	0.069	----	0.065	0.059	0.041	0.029	0.024	----	----
C_n'	20°	----	----	----	−.005	----	−.001	----	−.003	----	−.004	----	−.005	−.005	−.007	−.006	−.008	----	----
δ_{AF}	20°	----	----	----	23°	----	10°	----	6°	----	4°	----	4°	2°	2°	−3°	−11°	----	----

TABLE XIX

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation; $\frac{p'b}{2V}$ values are for free autorotation

	α	0°	12°	14°	16°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°	40°
10 per cent axis																			
(+) Rotation (clockwise).	C_λ	−0.023	−0.020	−0.018	−0.015	−0.026	----	0.014	----	0.017	----	----	−0.013	----	----	----	----	−0.009	−0.008
	$\frac{p'b}{2V}$	----	----	----	----	----	0.118	.122	0.139	.152	0.168	----	----	----	----	----	----	----	----
(−) Rotation (counter-clockwise).	C_λ	−.020	−.017	−.017	−.014	−.007	----	−.028	----	.003	----	----	.005	----	----	----	----	−.002	−.005
	$\frac{p'b}{2V}$	----	----	----	----	----	----	----	.167	.062	.073	0.074	----	0.068	0.055	0.036	----	----	----
15 per cent axis																			
(+) Rotation (clockwise).	C_λ	−0.024	−0.020	−0.018	−0.016	−0.002	----	0.020	----	0.027	----	----	−0.014	----	----	----	----	−0.009	−0.008
	$\frac{p'b}{2V}$	----	----	----	----	----	0.128	.149	0.165	.192	----	----	----	----	----	----	----	----	----
(−) Rotation (counter-clockwise).	C_λ	−.020	−.015	−.014	−.013	−.007	----	−.027	----	.004	----	----	.006	----	----	----	----	−.002	−.005
	$\frac{p'b}{2V}$	----	----	----	----	----	----	----	----	.069	0.078	----	.083	----	0.067	----	0.034	----	----
20 per cent axis																			
(+) Rotation (clockwise).	C_λ	−0.023	−0.022	−0.016	−0.014	0.003	0.012	0.014	0.016	0.018	----	----	−0.013	----	----	----	----	−0.009	−0.007
	$\frac{p'b}{2V}$	----	----	----	----	----	.107	.113	.141	.156	----	----	----	----	----	----	----	----	----
(−) Rotation (counter-clockwise).	C_λ	−.021	−.017	−.016	−.013	−.005	−.020	−.028	.004	.004	----	----	.007	----	----	----	----	.000	−.004
	$\frac{p'b}{2V}$	----	----	----	----	----	----	----	.186	.075	0.085	----	.087	----	0.074	----	0.043	----	----

TABLE XX

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation

	α	0°	12°	14°	16°	18°	20°	22°	25°	30°	40°
10 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.016	0.008	0.012	0.019	0.029	0.047	0.067	0.055	0.032	0.019
(+) Rotation (clockwise)	C_λ	−.029	−.045	−.048	−.054	−.064	−.073	−.072	−.064	−.046	−.030
15 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.019	0.006	0.010	0.016	0.027	0.046	0.066	0.055	0.031	0.018
(+) Rotation (clockwise)	C_λ	−.028	−.044	−.048	−.053	−.063	−.072	−.070	−.062	−.044	−.034
20 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.021	0.005	0.009	0.015	0.029	0.048	0.066	0.056	0.033	0.020
(+) Rotation (clockwise)	C_λ	−.028	−.043	−.047	−.053	−.063	−.072	−.071	−.062	−.046	−.034

TABLE XXI

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW=0°

α	δ_A	−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
AILERONS FLOATING NEUTRAL—10 PER CENT AXIS																			
C_L	0°	−0.256	0.015	0.130	0.301	0.606	0.880	0.984	1.065	1.115	1.100	1.083	1.043	0.950	0.675	0.612	0.623	0.576	0.493
C_D	0°	.047	.018	.018	.021	.042	.076	.093	.110	.134	.149	.161	.194	.222	.321	.378	.551	.698	.834
δ_{AF}	0°	15°	5°	2°	−3°	−9°	−14°	−17°	−19°	−21°	−21°	−22°	−24°	−25°	−22°	−28°	−35°	−40°	−40°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°				0.032		0.032		0.030		0.031		0.019	0.031	0.031	0.037	0.024		
C_n'	10°				.001		.002		.003		.003		.003	.002	−.004	−.006	−.006		
δ_{AF}	10°				10°		−4°		−9°		−12°		−13°	−15°	−15°	−19°	−27°		
C_l'	20°				.066		.069		.070		.071		.057	.067	.064	.066	.047		
C_n'	20°				.002		.006		.006		.006		.005	.003	−.003	−.005	−.006		
δ_{AF}	20°				20°		7°		3°		0°		−2°	−3°	−13°	−12°	−20°		
C_l'	30°				.103		.104		.086		.086		.084	.089	.089	.093	.070		
C_n'	30°				.001		.003		.003		.003		.003	.003	.000	−.003	−.006		
δ_{AF}	30°				30°		20°		14°		12°		8°	6°	1°	−3°	−12°		
AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																			
C_L	0°	−0.218	0.062	0.177	0.326	0.640	0.917	1.025	1.098	1.140	1.123	1.115	1.048	0.976	0.693	0.638	0.634	0.590	0.500
C_D	0°	.048	.021	.018	.021	.042	.074	.093	.109	.130	.144	.161	.191	.220	.323	.394	.547	.707	.837
δ_{AF}	0°	19°	12°	4°	0°	−5°	−10°	−12°	−14°	−16°	−17°	18°	−20°	−17°	−19°	−24°	−31°	−37°	−45°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°				0.032		0.031		0.031		0.030		0.022	0.028	0.029	0.036	0.025		
C_n'	10°				−.001		.000		.001		.002		.002	.001	−.004	−.006	−.006		
δ_{AF}	10°				11°		−3°		−8°		−11°		−14°	−15°	−18°	−20°	−20°		
C_l'	20°				.065		.068		.066		.062		.065	.064	.062	.067	.048		
C_n'	20°				.001		.004		.005		.005		.005	.002	−.004	−.006	−.003		
δ_{AF}	20°				22°		8°		4°		1°		−2°	−3°	−6°	−10°	−29°		
C_l'	30°				.103		.102		.082		.084		.088	.085	.081	.091	.070		
C_n'	30°				−.002		.002		.002		.001		.002	.002	−.003	−.006	−.007		
δ_{AF}	30°				38°		21°		17°		13°		11°	7°	5°	0°	−10°		
AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																			
C_L	0°	−0.105	0.092	0.216	0.383	0.672	0.951	1.050	1.128	1.159	1.154	1.142	1.065	1.003	0.705	0.643	0.648	0.610	0.518
C_D	0°	.047	.023	.019	.024	.043	.075	.091	.110	.132	.147	.162	.195	.224	.330	.400	.560	.719	.850
δ_{AF}	0°	21°	14°	13°	7°	−1°	−6°	−8°	−11°	−13°	−14°	−15°	−15°	−17°	−18°	−25°	−29°	−34°	−42°
RIGHT AILERON UP—LEFT AILERON DOWN																			
C_l'	10°				0.031		0.031		0.031		0.031		{0.021, 0.030}	0.030	0.030	0.034	0.026		
C_n'	10°				.000		.000		.000		.000		.000	−.001	−.005	−.006	−.006		
δ_{AF}	10°				11°		−1°		−4°		−7°		−10°	−11°	−13°	−18°	−24°		
C_l'	20°				.066		.068		.066		.062		.062	.063	.062	.068	.048		
C_n'	20°				.000		.003		.004		.005		.004	.000	−.005	−.007	−.009		
δ_{AF}	20°				22°		10°		6°		1°		−2°	−4°	−7°	−12°	−19°		
C_l'	30°				.103		.097		.083		.081		{.080, .090}	.085	.087	.091	.070		
C_n'	30°				−.003		.001		−.001		.000		.000	.003	−.009	−.007	−.008		
δ_{AF}	30°				31°		21°		16°		13°		9°	5°	4°	0°	−10°		

TABLE XXII

FORCE TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

α	δ_A	−10°	−5°	−3°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS FLOATING, NEUTRAL—10 PER CENT AXIS																	
C_L	0°	−0.241	0.033	0.144	0.296	0.554	0.755	0.841	0.910	0.967	0.982	0.994	0.990	0.938	0.688	0.622	0.621	0.586	0.492
C_D	0°	.060	.038	.037	.039	.055	.079	.093	.109	.128	.137	.148	.185	.224	.337	.387	.529	.690	.807
C_l'	0°	−.003	−.004	−.007	−.011	−.020	−.013	−.016	−.020	−.028	−.032	−.041	−.062	−.062	−.079	−.045	−.033	−.027	−.024
C_n'	0°	.003	.004	.004	.005	.006	.007	.008	.010	.012	.013	.014	.016	.017	.022	.023	.026	.031	.033
δ_{AF}	0°	12°	6°	3°	−1°	−9°	−13°	−15°	−17°	−19°	−20°	−21°	−23°	−25°	−33°	−37°	−47°	−56°	−64°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.060	--------	0.047	--------	0.070	--------	0.074	--------	0.076	0.076	0.052	0.043	0.028	--------	--------
C_n'	20°	--------	--------	--------	.000	--------	.008	--------	.006	--------	.005	--------	.003	.001	−.002	−.005	−.005	--------	--------
δ_{AF}	20°	--------	--------	--------	21°	--------	5°	--------	3°	--------	1°	--------	−3°	−4°	−5°	−6°	−14°	--------	--------
		AILERONS FLOATING, NEUTRAL—15 PER CENT AXIS																	
C_L	0°	−0.242	0.047	0.162	0.315	0.576	0.774	0.857	0.934	0.979	0.998	1.019	1.003	0.946	0.672	0.616	0.620	0.578	0.488
C_D	0°	.058	.038	.039	.040	.055	.076	.090	.105	.128	.135	.146	.184	.222	.329	.385	.535	.683	.812
C_l'	0°	−.004	−.004	−.005	−.009	−.015	−.009	−.013	−.017	−.025	−.031	−.037	−.056	−.062	−.087	−.047	−.032	−.026	−.025
C_n'	0°	.002	.003	.003	.004	.005	.006	.008	.010	.012	.013	.014	.016	.018	.024	.023	.026	.031	.034
δ_{AF}	0°	13°	8°	5°	1°	−4°	−10°	−12°	−14°	−17°	−18°	−19°	−21°	−23°	−28°	−38°	−49°	−57°	−62°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.060	--------	0.052	--------	0.045	--------	0.070	--------	0.075	0.075	0.058	0.040	0.027	--------	--------
C_n'	20°	--------	--------	--------	−.002	--------	.008	--------	.007	--------	.003	--------	.001	.000	−.005	−.005	−.005	--------	--------
δ_{AF}	20°	--------	--------	--------	23°	--------	6°	--------	1°	--------	1°	--------	−3°	−4°	−5°	−6°	−13°	--------	--------
		AILERONS FLOATING, NEUTRAL—20 PER CENT AXIS																	
C_L	0°	−0.241	0.046	0.162	0.324	0.575	0.789	0.869	0.943	0.999	1.025	1.022	1.023	0.965	0.682	0.622	0.613	0.577	0.492
C_D	0°	.059	.038	.039	.040	.055	.078	.091	.105	.124	.134	.146	.182	.222	.336	.390	.536	.689	.817
C_l'	0°	−.005	−.005	−.006	−.009	−.015	−.007	−.007	−.012	−.019	−.024	−.032	−.044	−.054	−.087	−.047	−.031	−.027	−.026
C_n'	0°	.002	.004	.004	.005	.006	.007	.008	.010	.012	.013	.015	.016	.018	.025	.024	.027	.032	.035
δ_{AF}	0°	13°	8°	6°	3°	−6°	−11°	−12°	−14°	−14°	−15°	−16°	−18°	−20°	−25°	−40°	−50°	−58°	−67°
		RIGHT AILERON UP—LEFT AILERON DOWN																	
C_l'	20°	--------	--------	--------	0.057	--------	0.057	--------	0.057	--------	0.061	--------	0.065	0.064	0.058	0.036	0.024	--------	--------
C_n'	20°	--------	--------	--------	−.003	--------	.001	--------	.001	--------	.000	--------	−.001	−.002	−.005	−.004	−.007	--------	--------
δ_{AF}	20°	--------	--------	--------	22°	--------	10°	--------	5°	--------	2°	--------	−1°	−4°	−4°	−6°	−9°	--------	--------

TABLE XXIII

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°, AND TRIANGULAR END PLATES

R. N.=609,000; VELOCITY= 80 M. P. H.; YAW=0°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation; $\frac{p'b}{2V}$ values are for free autorotation

	α	0°	12°	14°	16°	18°	19°	20°	21°	22°	23°	24°	25°	26°	28°	30°	40°
		10 per cent axis															
(+) Rotation (clockwise)	C_λ	−0.022	−0.020	−0.018	−.013	0.002	-------	0.020	-------	0.021	-------	-------	−0.010	-------	-------	−0.010	−0.006
	$\frac{p'b}{2V}$	-------	-------	-------	-------	.099	0.137	.149	0.204	.228	-------	-------	-------	-------	-------	-------	-------
(−) Rotation (counterclockwise)	C_λ	−.020	−.016	−.016	−.012	−.006	-------	−.028	-------	.007	-------	-------	.009	-------	-------	−.007	−.007
	$\frac{p'b}{2V}$	-------	-------	-------	-------	-------	-------	-------	.209	.167	0.123	0.117	.111	0.094	0.028	-------	-------
		15 per cent axis															
(+) Rotation (clockwise)	C_λ	−0.023	−0.020	−0.018	−0.014	.001	-------	0.016	-------	.020	-------	-------	−0.010	-------	-------	−0.009	−0.008
	$\frac{p'b}{2V}$	-------	-------	-------	-------	.096	0.145	.144	0.182	.223	-------	-------	-------	-------	-------	-------	-------
(−) Rotation (counterclockwise)	C_λ'	−.019	−.016	−.015	−.012	−.005	-------	−.030	-------	.003	-------	-------	.009	-------	-------	−.004	−.006
	$\frac{p'b}{2V}$	-------	-------	-------	-------	-------	-------	-------	.211	.167	0.116	-------	.111	0.097	0.043	-------	-------
		20 per cent axis															
(+) Rotation (clockwise)	C_λ	−0.022	−0.021	−0.018	−0.014	0.001	-------	0.015	-------	0.018	-------	-------	−0.010	-------	-------	−0.008	−0.006
	$\frac{p'b}{2V}$	-------	-------	-------	-------	.079	0 116	.124	0.170	.225	-------	-------	-------	-------	-------	-------	-------
(−) Rotation (counterclockwise)	C_λ	−.020	−.017	−.014	−.011	−.005	-------	−.028	-------	.005	-------	-------	.007	-------	-------	−.004	−.005
	$\frac{p'b}{2V}$	-------	-------	-------	-------	-------	-------	-------	.210	.167	0.109	-------	.106	0.100	0.050	-------	-------

TABLE XXIV

ROTATION TESTS. 10 BY 60 INCH CLARK Y WING WITH CLARK Y TIP AILERONS 100 PER CENT c BY 20 PER CENT $b/2$; FLAPS UP 11°, TRIANGULAR END PLATES

R. N.=609,000; VELOCITY=80 M. P. H.; YAW= −20°

AILERONS FLOATING AND NEUTRAL

C_λ is given for forced rotation at $\frac{p'b}{2V}=0.05$, (+) aiding rotation, (−) damping rotation

	α	0°	12°	14°	16°	18°	20°	22°	25°	30°	40°
10 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.013	−0.002	0.003	0.011	0.025	0.041	0.066	0.052	0.030	0.019
(+) Rotation (clockwise)	C_λ	−.031	−.037	−.041	−.046	−.055	−.063	−.073	−.059	−.047	−.036
15 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.014	−0.006	−0.001	0.006	0.022	0.038	0.063	0.057	0.028	0.018
(+) Rotation (clockwise)	C_λ	−.030	−.033	−.037	−.042	−.052	−.060	−.068	−.066	−.045	−.034
20 per cent axis											
(−) Rotation (counterclockwise)	C_λ	−0.016	−0.006	−0.004	0.003	0.017	0.033	0.061	0.056	0.031	0.018
(+) Rotation (clockwise)	C_λ	−.030	−.029	−.033	−.038	−.047	−.055	−.065	−.064	−.040	−.034

TABLE XXV

CRITERIONS SHOWING RELATIVE MERITS OF AILERONS

Subject	Criterion	Plain ailerons: 25 per cent c by 40 per cent $b/2$ (assumed standard size)	Plain ailerons: 40 per cent c by 30 per cent $b/2$ (rigged up 10° when neutral)	Symmetrical floating tip ailerons 100 per cent c by 20 per cent $b/2$; flaps 0°, no end plates; floating ailerons 40° difference.			Symmetrical floating tip ailerons 100 per cent c by 20 per cent $b/2$; 15 per cent axis; flaps 0°; floating ailerons 40° difference		Symmetrical floating tip ailerons 100 per cent c by 20 per cent $b/2$; flaps 2° up, no end plates; floating ailerons 40° difference.		
		Standard δ=25° up 25° down	Differential No. 2 δ=50° up 7° down	10 per cent axis	15 per cent axis	20 per cent axis	Circular end plates	Triangular end plates	10 per cent axis	15 per cent axis	20 per cent axis
Wing area or minimum speed.	Maximum C_L (δ_A=0°)	1.270	1.173	1.074	1.098	1.117	1.102	1.103	1.090	1.115	1.130
Speed range	Max C_L/Min C_D (δ_A=0°)	81.9	65.2	59.8	64.6	50.8	61.2	69.0	67.7	68.0	60.4
Rate of climb	L/D at C_L=0.70 (δ_A=0°)	15.9	17.1	12.1	12.7	12.5	13.6	13.5	13.1	13.3	13.7
Lateral controllability	RC α=0°	.204	.248	.299	.304	.342	.224	.263	.262	.269	.294
	RC α=10°	.076	.075	.086	.085	Ailerons flutter.	.072	.078	.079	.082	Ailerons flutter.
	RC α=20°	.038	[1] .076	.065	.065	.062	.057	.053	.061	.003	.007
	RC α=30°	.017	.027	.092	.091	.091	.115	.013	.090	.092	.089
Lateral control with sideslip.	Maximum α at which ailerons will balance C_l' due to 20° yaw.	20°	26°	21°	20°	20°	All Angles.	25°	20°	20°	20°
Yawing moments due to ailerons; (+) favorable, (−) unfavorable.	C_n α=0°	−.007	.021	.002	.001	.001	.001	.002	[2] .001 / −.001	-------	−.001
	C_n α=10°	−.004	.026	.018	.016	Ailerons flutter.	.016	.017	.015	.014	Ailerons flutter.
	C_n α=20°	−.010	.030	.033	.030	.028	.026	.025	.029	.027	.029
	C_n α=30°	−.008	.009 / [2] .001	.030	.029	.029	.037	.030	.028	.027	.027
Lateral stability (δ_A=0°).	α for initial instability in rolling	18°	20°	20°	20°	19°	19°	19°	20°	19°	19°
	α for initial instability at $p'b/2V$=0.05: Yaw=0°	17°	19°	18°	19°	18°	18°	18°	18°	18°	18°
	Yaw=20°	11°	13°	10°	10°	10°	[2] 4°	13°	10°	10°	10°
	Maximum unstable C_λ: Yaw=0°	.048	.015	.018	.017	.017	.017	.025	.018	.018	.020
	Yaw=20°	.093	.072	.061	.061	.062	.047	.062	.064	.062	.065

Footnotes at end of table.

TABLE XXV—Continued

CRITERIONS SHOWING RELATIVE MERITS OF AILERONS—Continued

Subject	Criterion	Symmetrical floating tip ailerons 100 per cent c by 20 percent $b/_2$; flaps 2° up; triangular end plates; floating ailerons 40° difference.			Clark Y floating tip ailerons 100 per cent c by 20 per cent $b/_2$; flaps 11° up, no end plates; floating ailerons 40° difference.			Clark Y floating tip ailerons 100 per cent c by 20 per cent $b/_2$; flaps 11° up, triangular end plates; floating ailerons 40° difference.		
		10 per cent axis	15 per cent axis	20 per cent axis	10 per cent axis	15 per cent axis	20 per cent axis	10 per cent axis	15 per cent axis	20 per cent axis
Wing area or minimum speed	Maximum C_L, $\delta_A=0°$	1.095	1.125	1.158	1.093	1.118	1.129	1.115	1.140	1.160
Speed range	Max C_L/Min C_D, $\delta_A=0°$	64.0	66.5	63.2	65.5	61.1	51.3	63.0	62.6	59.8
Rate of climb	L/D at $C_L=0.70$, $\delta_A=0°$	14.0	14.7	15.6	12.8	12.5	13.2	13.6	14.6	15.5
Lateral controllability	RC $\alpha=0°$	.216	.220	.175	.257	.273	.298	.218	.203	.169
	RC $\alpha=10°$	.072	.072	Ailerons flutter.	.087	.085	.083	.075	.071	.070
	RC $\alpha=20°$	.061	.051	.052	.065	.065	.064	.050	.056	.061
	RC $\alpha=30°$	.104	.104	.102	.090	.090	.089	.096	.095	.089
Lateral control with sideslip	Maximum α at which ailerons will balance C_l' due to 20° yaw.	23°	23°	21°	20°	20°	20°	23°	23°	23°
Yawing moments due to ailerons; (+) favorable, (–) unfavorable.	C_n $\alpha=0°$	[2].001	----------	----------	.001	----------	–.001	.002	.001 [2]–.001	----------
	C_n $\alpha=10°$	.015	.015	Ailerons flutter.	.018	.016	.015	.017	.015	.014
	C_n $\alpha=20°$	.026	.022	.023	.032	.031	.029	.025	.027	.028
	C_n $\alpha=30°$	.029	.029	.029	.028	.028	.027	.029	.028	.037
Lateral stability ($\delta_A=0°$)	α for initial instability in rolling	19°	18°	18°	19°	19°	19°	18°	18°	19°
	α for initial instability at $p'b/2V=0.05$: Yaw=0°	18°	18°	18°	18°	18°	18°	18°	18°	18°
	Yaw=20°	12°	14°	15°	9°	10°	10°	13°	14°	16°
	Maximum unstable C_λ: Yaw=0°	.022	.020	.019	.017	.027	.018	.021	.020	.018
	Yaw=20°	.057	.061	.059	.067	.066	.066	.066	.063	.061

[1] RC has a minimum value of 0.063 at $\alpha=17°$ and a maximum of 0.086 at $\alpha=22°$.
[2] Where the maximum yawing moments occur below maximum aileron deflection, the number 2 indicates that the deflection of the up aileron was 10°.
[3] This wing is unstable from $\alpha=4°$ to $\alpha=8°$ and is stable from $\alpha=9°$ to $\alpha=16°$, above $\alpha=16°$ the wing is unstable.

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